

Pottery specialization, social organization and the origin of early state: the comparison study between Taosi Culture and Erlitou Culture

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Doctoral Dissertation

Pottery specialization, Social organization and the Origin of Early State: the
Comparison Study between Taosi Culture and Erlitou Culture
土器の専門化、社会組織と初期国家の起源: 陶寺文化と二里头文化の比較研究

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Abstract

Craft specialization and social complexity have been traditionally viewed as closely related, with craft specialization often considered a key factor in the formation of early states. However, recent studies have focused on explaining the dynamic and specific relationship between craft specialization and certain aspects of social complexity, rather than testing simple evolutionary relationships. Pottery, as an important craft product in ancient societies, can provide valuable insights into the social context of production and the political and social structures of past economies. However, there are several problems with the study of pottery production and specialization in the formation of early Chinese states, such as an overemphasis on prestige pottery and oversimplification of the relationship between pottery production and state formation. Thus, it is necessary to re-examine pottery production during the formation of early Chinese states and distinguish the particular paths and relationships between pottery specialization and early state formation.

To achieve this goal, this research chose two cultures, the Taosi and Erlitou cultures, as case studies. These two cultures represent the pre-state period and the early state stage, respectively, providing information about the specific trajectory of the early state in China. The study of pottery from these two cultures offers a clear and specific view of the relationship between pottery specialization and early state formation in China. This study adopts a dynamic perspective to examine pottery production specialization in three dimensions: craft landscape, standardization and differentiation, and exchange and consumption patterns. Multiple quantitative methods, including various geometric morphometric analysis (GMM), coefficient of variation (CV) algorithms, and multivariate analysis, were applied to investigate different components of the pottery production system. These applications allow for a more objective comparison of data between the two cultures and overcome the subjectivity of traditional typologies and the interference of previous evolutionary models.

This dissertation finds that during the formation of the early Chinese state, pottery production became more complex, and the degree of specialization deepened overall. This included changes in the production of prestige pottery under the increasing intervention of the elite, as well as in the specialization of the production of ordinary pottery during the labor division and urbanization processes. However, from a detailed perspective, the production of pottery during the formation of the early Chinese state shows a different pattern than previously expected. Firstly, by comparing the degree of change of ordinary and prestige pottery, the study found that the degree of specialization change in prestige pottery was much higher than that of ordinary pottery, indicating that political power played an important role in influencing pottery production during the early states formation in China. In addition, the three dimensions of pottery specialization showed asynchronous changes in the process, illustrating the dynamics of pottery specialization in the state formation process. Even during the Erlitou period, prestige pottery production was not centrally controlled within the political economy system. The Erlitou palace elite gained white pottery from a distant workshop but did not fully control production. Such behavior was probably due to the limited power in the early period of the political integration process and the preciousness of white pottery compared with bronze and turquoise. The research also found that the production of ordinary pottery existed in more diverse forms in Erlitou society compared with Taosi society due to the diverse social organization and different consumption traditions in the early state.

Therefore, the relationship between specialization in pottery production and early state formation is dynamic. Although there is a strong link between deepening specialization and social complexity in general trends, pottery specialization does not necessarily correspond simply to social changes. The relationship is also determined by the function of the pottery, its social significance, and the political strategy in the early formation process.

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CHAPTER 1 INTRODUCTION

1.1 Background

Craft specialization and social complexity are often considered to be closely linked. In studies of ancient civilizations around the world, the emergence of early states is related to a high degree of craft specialization such as that in ancient Maya, Egypt, and Mesopotamia (eg. Costin, 1991; Blackman et al., 1993; Lass, 2008; Underhill, 1996). As a material manifestation of social complexity, craft specialization is usually considered a key factor in the state period. For example, Childe (1950) mentions in *his book Urban Revolution* that during the formation of the Mesopotamian state, the elite control of social surplus contributed to the emergence and development of craft specialization, and under this influence, specialized craftsmen were under elite control. Political control was the main motive for the emergence and development of specialization (Trigger, 2003; Wailes, 1996). But this relationship was discredited after the 1980s, when it was argued that such an idea was too simplistic in describing the diversity of possible forms of production specialization and the relationship between production activities and the social system (Stein, 1994).

In the following three decades, many scholars concluded more forms of production organization and the diverse possibility of a complex relationship with society complexity (Costin, 1991, 2005). The specialization could be divided into independent and attached based on different production context and also into different levels from household, community, workshop to industry (Costin, 1991). Then, the arguments about the relationship between them include not only the political model under political control but also the adaptive model to a natural and social environment and the economic model driven by economic interests and the deepening of the division of labor (Brumfiel and Earle, 1987).

Furthermore, craft production's single correspondence to social forms is also challenged by the idea that there is a dynamic relationship between craft specialization and social complexity (Duistermaat, 2016). To begin with, a single model does not

adequately explain craft production and specialization in a given society, and it has been discovered that different types of craft production organizations with different levels of specialization and combinations of specialized and unspecialized production can exist concurrently in the same society (Costin, 2005). So, a single evolutionary trajectory of craft specialization is not appropriate. Secondly, the discussion of craft production and specialization needs to take into account the influence of the whole society, in addition to political factors such as the dynamic process through which the elite support themselves, maintain legitimate status, and negotiate social relations; the natural environmental factors; the economic system; the properties of the craft products themselves, and even the agency of the craftsmen themselves should also be considered (Duistermaat, 2016; Hodder, 2011). Furthermore, the entangled relationship between the non-elite and political economies has received a great deal of attention in recent years (Costin, 2005), as the previous dichotomy was thought to be insufficient to fully explain the complex forms and diversity of production forms (Stein, 2001). Therefore, the previous single models and correspondence relations are not sufficient to explain the dynamic link between craft specialization and social complexity. The growing number of diverse archaeological cases also proves that the level of craft specialization and the relationship between the formation of the state are not static but need to be studied in the context of a particular society, taking into account the multiple factors of social change.

Pottery, as one of the important craft products of ancient society, was not only a widely produced product for use but was also often closely related to the political behavior of the elite (Roux, 2019). Thus, pottery can reflect not only the production behavior of potters, but also the different social consumption patterns and organizational structures of society. As a result, archaeologists can gain perspective on the social context of production and track both change and continuity in the political and social structure of past economies. Thus, understanding the specialization of pottery production is an important topic and has implications for the study of social complexity, particularly in the emergence of early states.

However, there are several problems with the study of pottery production and specialization in the formation of early Chinese states. First, in Chinese archaeological research, the focus of research on the changes in the specialization of craft production in the early state formation process has been mainly on prestige goods under political control, focusing mainly on bronze, jade, turquoise, and to a lesser extent on precious pottery, etc. (Underhill, 2002). Such types of prestige items are considered to be produced under the centralized control of the political-economic model (Liu and Chen, 2012). In this situation, the central elite tightly controls the precious raw materials, advanced technology, craftsmen, and redistribution pattern. However, such a centralized model has been met with skepticism in recent years, with some claiming that there is no direct evidence response and that further investigation is required (Campbell et al., 2022). In addition, although some research focuses on the changes in ordinary pottery production in the social complexity process, some disagreements remain regarding the relationship between the specialization of pottery production and the complexity of Chinese society. Whether the tendency toward specialization from decentralized to centralized production of pottery in the state formation process has given rise to a series of different opinions, some researchers apply the evolutionary model and agree that there was a tendency toward pottery specialization from Neolithic time to the early state (Dai, 2010). Others, on the other hand, believe that ordinary pottery is the decentralized form in such a social complexity process, as opposed to prestige pottery with elite control (Underhill, 1996). As a result, the changing patterns of pottery production specialization during early Chinese state formation, as well as the relationship between the two, need to be studied more explicitly and thoroughly.

Based on these considerations and considering the tendency of pottery production research over the years, it is necessary to re-analyze pottery production during the formation of the early Chinese state and to distinguish the particular paths and relationships of pottery specialization in the context of specialization theory.

1.2 Research goals and significance

In general, the goal of this study is to clarify the relationship between pottery production systems, specialization, and the formation of the early Chinese state. The study of pottery production behavior in this paper is not only concerned with production itself but also with the entangled relationship between pottery specialization and social complexity in the context of particular social changes. Therefore, this study intends to examine the specific link between such a special trajectory of pottery production and the formation of early states, based on the changes in production specialization in conjunction with the social complexities of Chinese society and the paths of early state formation.

First, the pottery production system is dynamic, and the changes in specialization are not evolutionary or uniform. There may be synergistic changes in multiple directions and factors, so it is necessary to examine the situation of each production factor and the changes in the relationship between them in a comprehensive way in order to figure out the changes and mechanisms in the production specialization. Secondly, the relationship between the specialization of pottery production and social complexity is complex. Pottery production is not a purely adaptive behavior for society and economy, but it is also influenced by various social system components. It is a social behavior related to social organizational structures, socio-political structures, ritual systems, etc. It is necessary to analyze production behavior in the context of a particular environment and social system. It cannot be imposed on a specific society by a predetermined model. Therefore, the study held a dynamic view to study the pottery specialization from three dimensions. Based on this, the social context is then carefully analyzed to examine the dynamics and mechanisms of changing or unchanging specialization dimensions and to explain the possible relationship between pottery production specialization and the early state in the context of the particular trajectory and characteristics of early Chinese state formation.

Such a research workflow and goal can eliminate the single evolutionary model and provide a comprehensive perspective on the development and mechanisms of

pottery specialization. The close integration with specific social contexts can also be explained from a dynamic perspective, which is required by cultural diversity and specificity. This study attempts to address the gap in previous studies on pottery specialization during the formation of the early Chinese state through this line of research. At the same time, the research may also enrich more cases of archaeological practices worldwide for understanding craft specialization and social complexity.

In addition, the quantitative study of pottery in the research method is another important feature of this paper. Quantitative research has been a popular approach to the study of pottery specialization in recent years, usually by quantitatively analyzing various attributes of the pottery, such as shape, size, and clay composition, in order to examine their standardization or by quantitatively comparing the clay to examine possible exchange behavior (Bishop, 2019). While such methods are common in Europe and the United States, quantitative studies of pottery in China are less common and suffer from some statistical ambiguities in quantitative methods and a lack of discussion of production relations and related social implications in conjunction with quantitative results. For example, the problem of synchronicity of data is not noted in most examinations of pottery standardization, which can easily lead to misleading results (Deng et al., 2022). Therefore, this study also plans to illustrate and clarify the quantitative study of pottery so as to contribute to the subsequent better application of quantitative research in studies of pottery production.

In summary, this study is a multi-level, comprehensive, and dynamic study that seeks to answer the questions of the relationship between pottery production specialization and social complexity in the early state process and will provide several impacts both in the theory of production specialization and social complexity and in the quantitative methods of pottery examination.

1.3 Research objectives, methods, and dataset

This paper chooses the Taosi culture and the Erlitou culture of China as case studies to examine the relationship between pottery specialization and social

complexity. The Taosi site is situated in Shanxi Province, dated from 2300-1900BC, and is considered a typical sample of the highly complex chiefdoms in pre-state China (Zhongguo et al., 2015c). Many scholars regard the Erlitou culture, centered on the Erlitou site, as China's first early state (Liu, 2005). It dates from 1750-1520 BC (Zhongguo, 2014). The two cultures are in successive stages of social development; they share some characteristics in social structure, but certain differences in the degree of complexity have shown themselves in the two cultures, which imply the process of state formation in China. Therefore, these two case studies can provide information about the specific trajectory of early China. Then, the rich pottery materials also satisfy the conditions for a comprehensive examination of pottery production.

Numerous forms of ceramic production-related evidence from the Taosi and Erlitou cultures were chosen for this study's material. As was said before, it is crucial to take into account each variable of specialization components in an integrated manner, so the study selected a variety of research materials for a thorough analysis. The study divides archaeological data into two categories: direct evidence and indirect evidence. Direct evidence includes the production tools, facilities, and debris related to production. Indirect evidence includes the recognition of a large number of more or less identical or standardized items, manufacturing proficiency (skill), manufacturing efficiency, and the identification of spatially discrete regional variations or the distribution of specific artifact types (Costin, 1991). It is about craft itself. The examination of production systems, especially production specialization, is not simply an analysis of a certain procedure in production activities or a certain attribute of pottery but is to include as much information and examination as possible to synthesize the situation of each component of the production system and to synthesize the entangled relationship between them and the whole production system.

This study uses multiple methods to quantify different pottery attributes. This research uses geometric morphometric analysis (GMM) and elliptical Fourier analysis (EFA) to quantify the shape attributes of pottery. Furthermore, the coefficient of variation (CV) algorithm was chosen to quantify the degree of standardization of size attributes. After using these two quantification methods, the paper uses multivariate

analysis for quantifying results, including principal component analysis, ANOVA, and MANOVA tests, to examine the specific situation, mechanisms, and causes of change in pottery attributes. In addition, for other components of production (which are not easily quantified), the study incorporates a number of other sub-approaches, including simple counting comparisons to examine possible changes in pottery production and consumption and spatial analysis to examine direct evidence.

In addition to allowing for a more visual comparison of data between two cultures, quantitative research approaches are effective in overcoming the subjectivity of traditional typologies and qualitative investigations. The use of such a wide range of research techniques enables an integrated and thorough analysis of the pottery production systems in both cultures as well as the level of specialization in the creation of various pottery types.

1.4 Dissertation structure

The following chapters cover a number of topics in order to provide a comprehensive study of the pottery production system and the degree of specialization in both cultures. In general, I describe and analyze the data based on a range of theories and research methods, followed by a discussion of the results I obtained.

Chapter 2 reviews some relevant theories and previous research on case studies that I use to address and approach current archaeological data. These theories of social change, state origins, and craft specialization provide the theoretical framework for my research. It has helped me think more deeply and innovatively about my data. On this basis, I introduce the conceptual framework about the pottery specialization and early state, built my research strategy, and formulated my research hypothesis to guide my subsequent analysis and discussion of the data.

Chapter 3 introduces the materials and methods of this study. The materials include pottery-making equipment, tools, and pottery from the Taosi and Erlitou sites. The study employs different quantitative methods for these different types of materials and the different properties of the pottery, mainly using GMM, CV calculations, and related

multivariate analysis methods to provide a more complete and comprehensive examination of the different pottery production methods that exist in the two cultures.

Chapters 4 and 5 examine the pottery production systems of the Taosi and Erlitou cultures, respectively. In these two chapters, the study begins with a comprehensive analysis of the social systems of the two societies through a summary analysis of previous studies and a re-quantitative analysis of mortuary behavior. Different social contexts are provided for the examination of the pottery systems. On this basis, pottery production in both societies will be examined through a quantitative study of the direct evidence and indirect evidence.

Chapter 6 concentrates on the analysis and discussion of the above results. In this chapter, I first test the hypotheses presented in Chapter 2 on the basis of the previously obtained results and answer the research questions. Second, based on answering the research questions, I summarize the pottery specialization changes from Taosi society to Erlitou society and analyze the specific features of these changes. Finally, I will discuss the relationship between these changes and the specific trajectory of early state formation in China.

Chapter 2 LITERATURE REVIEW

2.1 Introduction

Craft specialization is always mentioned in the study of social complexity and state formation. The degree and form of craft specialization are considered one of the indicators of social complexity. A growing number of researchers, however, have discovered that the mechanisms, and relationship between craft specialization and societal changes are complex and that specialization cannot be simply equated with social complexity. In this chapter, therefore, the study intends to provide a general theoretical exploration of the complex relationship between craft specialization and social complexity, especially state formation.

In the first part, I intend to review the previous theories and studies on social evolution and social complexity and to discuss the multiple theories on the formation of the state in particular, illustrating the dynamics of social complexity and the changes in social stratification and differentiation in the process of early state formation. In the second part, I intend to explain the general theory of craft specialization, including definitions, forms, a rethinking of the relationship with social complexity and early state formation. In response to the above two topics, I present the problems in previous research about the relationship between pottery specialization and early state formation. In response to the previous research gap, I propose a research question for this dissertation. I then developed my own conceptual framework by discussing how to identify the forms and changes of pottery specialization and build up the model by three steps to guide the whole dissertation. In this study, two case studies, the Taosi culture and the Erlitou culture, were chosen to test the above hypotheses. The continuity of the two social development stages, the basic consistency of their cultural connotations, the richness of their materials, and the important role they play in Chinese archaeology make them very suitable as case studies.

The research upholds the notion of focusing on production itself, considering that production behavior is a dynamic, specific result based on social context and individual

agency and does not correspond one-to-one with social types. We can only move away from previous rigid explanations of correspondence and causal pattern by thoroughly examining each component of the production system and clarifying how it changes in different societies. Finally, the special relationship between specialization, social complexity, and early state formation can be clarified.

2.2 Social evolution, complexity, and the origin of early states

2.2.1 General theory about social evolution and complexity

In recent decades, social change, also known as social evolution in some publications, has progressed from unilinear to multilinear evolutionary models. The most famous evolutionary model, proposed by Service (1962), summarizes the pattern of social evolution into the pattern: band-tribe-chiefdom-state, in which the chiefdom noun distinguishes the stages of pre-state societies and has given rise to extensive subsequent discussion and application (Service, 1962). Similarly, Fried (1967) divided the evolutionary trajectory of society into egalitarian-ranked society-stratified society-state society from the perspective of social relations. Although the words they used are different, the overall classification and trajectory of social characteristics are consistent. In the following decades, such a model has been modified and refined in several ways. For example, there may be a series of refinements to the chiefdom society, such as the division of chiefdoms into collective and individual chiefdoms with different socioeconomic and organizational structures. The chiefdoms may also be divided into simple chiefdoms and complex chiefdoms, depending on the degree of complexity. (Renfrew et al., 1974; Earle, 1978; 1991; Johnson and Earle, 2000)

After the 1980s, a critique of the unilinear evolutionary model arose, where the overly typological judgments of the above models may have oversimplified the mechanisms of social change. Yoffee (1993) proposed a possible diverse trajectory of social changes in the world, while unilinear development ignored such diversity. This led to the idea of a multilinear model to explain social evolution. The multilinear

evolutionary model mainly stresses the complexity and diversity of evolution's trajectory (Feinman and Joyce, 1998; White, 1995). In addition, Johnson and Earle (2000) tried to abandon the previous theory of segmented evolution and attempted to explain the trajectory of social change from a social organization perspective. They divided the whole of human society into 3 types of social organizations (the family-level group, the local group, and the regional polity) and emphasized that these social organizations can exist at any stage of society. The progress of the idea of multi-linear evolution is mainly reflected in the recognition of trajectory diversity. They contend that there is no single correspondence between economic form and social organization and propose that multiple economic types may exist within a single society form.

The above single- and multi-linear models of social evolution indicate the existence of different stages of social change in different natural and social environments, and the patterns and characteristics of development in the so-called Old World (Mesopotamia, Egypt, the Indus Valley, and China) are recognized on a macroscale (Stein, 2001). These evolutionary ideas provided the basis and theoretical framework for archaeologists to examine ancient societies and the characteristics of societies in different stages. But even though the multilineal evolutionary model critiqued the unilinear and valued the diversity of changes in different societies, it did not propose a new and more satisfactory model to explain social change. According to Chapman (2003), in all cases, a limited number of social types or forms are arranged in a process that progresses from simple to complex. Such frameworks do not include the necessary research on how a specific society works and changes.

After the 21st century, the term "evolution" has been increasingly abandoned to describe social change, and archaeologists are using the concept of "social complexity" more often to explain and examine changes in ancient societies. Applied to archaeology, the concept of complexity is primarily rooted in the idea of systems theory, which refers to the increase in the number of components in a social system and the diversification and complexity of their interrelationships (Flannery, 1972; Crumely, 2005). Complexity essentially refers to the "segregation" and "centralization" of society. Segregation generally means the degree of division of labor and specialization, and centralization

means the degree of association between the subsystems of society and the highest locus of control (Rothman, 2004). Arnold (1996) believes that social complexity is a process of transformation from simplicity to complexity, from equality to hierarchical differentiation, in terms of economic basis, social structure, and ideology. In addition, referring to biological systems, Crumley (2005) argues that complex systems are dynamic systems characterized by fast and slow events, organic and inorganic elements, and may undergo sudden changes and irreversible processes. This implies that social complexity is also a dynamic process with uneven space and less predictability.

With a social complexity framework, archaeologists looked at social change at different levels of complexity and saw "social evolution" as a multi-linear, specific, and dynamic change that affected different parts of society (Schortman and Urban, 2004; Crumley et al.(2007) believe that the complex concept's hierarchy and heterotopia ideas allow them to explain the process of social change from the perspective of the political organization to the individual. Furthermore, such flexibility makes the complexity idea more helpful than the rigid categorization approaches. Under such a shift in thinking, the discussion on the formation of the state has also undergone a change.

2.2.2 The origins of early states

The state was the product of a high degree of social complexity (Stein, 2001). It is generally believed that the most distinctive feature of a society in the state stage is the existence of a central authority and the legitimacy and permanence of the center of power. Compared to the chiefdom stage, state societies are more complex and centralized power is more specialized and institutionalized (Yoffee, 2004). Service (1962) argues that the state would have a professional, legalized bureaucratic government, while Fried (1967) believes the state should be defined by his institutions for the maintenance of stratified society. Common arguments for Fried and Service's model include stratification (i.e., social stratification based on factors other than age and gender), centralized leadership, and military force. In conjunction with the concept of information theory, Flannery argues that the state is able to have more functions to

maintain state rule through the control of information to hire soldiers, conduct warfare, and expand frontiers (1972). The state's elite group is at the top of the decision-making system and has access to more information to carry out regulatory activities (Wright and Johnson, 1975). Similarly, Feinman and Joyce (1998) argue that the classification of "service" is a useful starting point for comparative discussions but also adds to the state's ability to recruit soldiers, wage war, and hold conquered territory.

The elite's political power is regarded as a key to state formation. In discussing the process of forming a strong ruling system by the elite, other components of society also need to provide corresponding support and are influenced by this ruling system. The concept of state has been broadened to encompass the entire social system. The scholars established a comprehensive set of indicators to describe state formation (Table 1). Such criteria are widely applied to study ancient states around the world, for example, the Classic Maya and Valley of Mexico (Spencer and Redmond, 2004); early Shang in China (Chang, 1980, 1983, 1986); Mesopotamia and Egypt (Yoffee, 1995; Rothman, 2004).

Table 1 The features of the 'state'

Criteria of the state	Detailed information concluded by Claessen and Skanlinik (1978); Trigger (2003)
Population	Sufficient number
Social organization	Territory based instead of kinship based; Stratified
Political structure	Centralized government with functional institutions; Power to prevent fission and defense against external threats
Economy	A regular surplus; craft specialization
ideology	Common ideology to legitimized the ruling stratum

The above models all try to find a way to uncover universal rules and general laws to explain the discernment of state societies, the emergence of ancient states, and their motivations, trying to provide a criterion for the transformation from the chiefdom society to the state society. However, in recent years, questions have been raised about

programmatic uniformity, the lack of integration with specific archaeological contexts, and the danger of simplification.

Social change is a process, and more and more archaeologists are realizing that it is hard to find perfect cases to represent the direct evolution from so-called chiefdoms to state forms and the above criterias proposed for states seem only appropriate to describe and study mature states. Claessen and Skanlinik (1978) realized that not all early states had mature central government institutions, complete bureaucracies, complete outward-oriented markets and trade, and other features. The concept and characteristics of the early state were realized and separated from the state.

Early state refers to the earliest and pristine type of state from the pre-state period to the mature state (Khazanov, 1978). The study of the characteristics of the early state and how it gradually formed into a mature state is crucial to the complexity of society. The early state form was not an entirely new social model compared to the chiefdoms, but rather contained some features of the previous social form in a new form of organization (Claessen and Skanlinik, 1978). Early states were similar to chiefdoms in many ways, such as already having a stratified social structure, strong central leadership, and blood family or clan ties still shaping social relations (Yoffee, 2004). In addition, economically, complex chiefdoms already had control over subsistence and wealth resources and formed redistribution to sustain domination, as well as specialization in the production of some valuable crafts, division of labor, and long-distance exchange. All these features continued into the early state stage (Earle, 2002). Some scholars have illustrated that the greatest difference between early states and chiefdoms was in the political system and structure (Claessen and Skanlinik, 1978; Chen, 2007). But such political structures are often difficult to observed directly from material culture, which makes it difficult and controversial to separate and study early state forms.

Inspirely, Yoffee (2004) offered a new perspective as an alternative view to identify and study early state from the social intergration perspective instead of purely material culture. He argues that the key to early state formation was the creation of new groups and the need for a powerful central force when different groups reorganized into a social collective by transforming and pooling some symbolic and ritual resources. In this

premise, social and economic relations would show some new forms compared to the chiefdom society. This kind of thinking is also consistent with the social changes in the two perimeters of differentiation and concentration in complex societies. The early state was able to integrate the old and new groups in a variety of ways to maintain the equilibrium of the entire social system facing the increasing complex components appearing in the society. This was also the reason for the failure of many complex chiefdoms, which were unable to maintain the integrity and equilibrium of the whole society system in the face of increasingly complex social groups and social relations, leading to the collapse of the system(Beck, 2013). Therefore, the central government or the elite as the dominant group in the ever-divergent social organization to integrate the different unitites of the society and maintain the social equilibrium can be regarded as a major feature of the early state formation. In other words, the tendency of social integration, especially political integration, is an important feature of the early state different from the chiefdom society. Thus, an examination of the early state needs to focus on whether society produced a strong integrating force.

Under such consideration, how the various components of society are integrated in the process of state formation, how each relates to the other, how the elite carries out its dominant role, and how the non-right group approaches the integration of the dominant role (acceptance or rejection) could be the critical perspective to study early state formation. Inside these questions, the dominant role in economy, political and the common culture of the elite group can be regard as how power is rationally maintained and enhanced in this process(Figure 1). The government of the early state had strong economic power, and although it still held a dominant position in subsistence and commercial(wealth) activities and was able to allocate and control resources and wealth, the pattern and degree of such control was deeper than that of the chiefdom society in order to stabilize its position in the integration process(Earle, 2002).The state elite may hold more livelihood resource through tribute, taxes or other ways.Its material culture is expressed mostly in the form of special storage facilities. In commercial(wealth) activities, the early state may contain the extensive trading system and the complexity of economic relations(Earle, 1997). In the process of social integration, the need for

prestige craft items would become more urgent to gradually regularize and institutionalize power (Chen, 2007). Driven by such motives, the exclusivity of specialized production would further increase and be subject to deeper control. Furthermore, long-distance trade would be fixed and expanded as the need for political power increases (Spencer, 1994). In the chiefdom society, although long-distance trade also existed, it was limited to a very small number of products, and the control of raw materials for valuable handicrafts was mainly distributed around the center settlement, generally within 20km far, which is the distance of a day's round trip (Hirth, 1996 ;Liu, 2005). The early state, however, greatly expanded the range and depth of trade flows under an organizational division of labor with specialized decision-making allocations (Stein, 2001). Although long-distance exchange in the state is usually considered a form of tribute, a growing body of research indicates that in the early state, where power remained somewhat primitive, the forms of long-distance exchange may have been diverse (Chapman, 2003). Therefore, economy prevelidge in wealth a fundamental feature of early states, and the ability of state societies to create and institutionalize it was far greater than that of previous chiefdom societies, reflecting greater economic power and the ability to integrate social wealth resources. Furthermore, in terms of social power, the early state also showed differences from chiefdom societies in the process of unification and integration. Chiefdom societies usually relied on blood kinship and divine empowerment to identify chiefs socially (Service, 1962; Earle, 1991,1997). An important aspect of social power in the early state, with its deepening urbanization and regional ties, was the creation and/or adaptation of symbols of cultural commonality. Such symbols were no longer purely blood or religious, but used a variety of means including ritual, feasting activities, architecture, precious objects, art or literature, to transcend the roles assigned by kinship and confer prestige on those who could perform rituals and maintain community symbols. These actions can legitimize the unequal order of these people and integrating local rulers into a centralized and unified ritual and social organization (Baines and Yoffee, 1998; Yoffee, 2004).Tn this way, the control of knowledge, rituals, and symbols by the state elite was significantly different from that of the chiefdom society, reflecting the increased ability of early state

leaders to integrate social relations. In addition, the change is more pronounced in political power. Early states needed stronger political power to avoid social breakdown, resulting in changes in the management of both internal government levels and local groups (Claessen and Skalník, 1978). Although mature states had strong armies and specialized administrators, the kinship of the early states did not completely withdraw from the realm of political power, and thus showed a certain primitiveness and laxity. However, the deepening pursuit of political power in the early state compared to the pre-state societies is already indisputable. Overall, all three major dimensions of elite power and the different means of achieving it - the struggle for control over economic resources, control over knowledge, rituals and symbols, and control over administrative and armed forces - needed to develop together for the state to emerge. This gave rise to the new social, political, and economic relations that also characterized the early state in order to achieve the social integration.

Furthermore, the formation trajectories and characteristics of early states were extremely diverse. Current archaeological discoveries reveal a wide variety of differences in early state forms in various regions of the Old and New Worlds. For example, the early states of Egypt and the Indus Valley were established under a highly centralized political system over a wide area (Janssen, 1978; Maisels, 1999), while the early states of the Uruk period in the Mesopotamian plain were more clustered in cities, controlled by the nobility, with relatively autonomous regions outside the cities (Stein, 1994); In the ancient Maya, environmental constraints led to a diversity of agricultural and artisanal products, and the aristocracy developed early states by controlling trade and integrating economic, military and political functions with divine authority (Schaedel, 1978). In the ethnographic cases of the New World, and in Samoa early state society there is a self-contained economy, surplus products were collected and redistributed centrally among social groups through the principle of reciprocity. Therefore, the diversity of early state forms makes it difficult to examine and judge the formation of particularly early states by universal quantitative criteria. The examination of early state formation must pay close attention to cultural specificity and the integration of cultural contexts.

Finally, while the differences in political structures mentioned above are the most obvious feature of the early states, the overemphasis on political power and the elite group could also lead misunderstanding. As Chapman (2003) argued, the above discussions focus on characteristics such as legitimized force, bureaucratic government, and centralized decision-making. In the research of Mesopotamian archaeology, the model of "state as manager" or "elite decision" has been criticized for neglecting other important issues such as inequality and exploitation, the heterogeneity of the social organizational structure, and the relationship between production and consumption, etc. (Pollock, 1992; Stein, 1994) Researchers tend to seek more integrated ideas toward state formation than a top-down approach. State societies are more often considered heterogeneous entities in which the agency, production relations, power relations, and ideology between different socio-economic groups play an important role in shaping the fundamental structure of society rather than the mere centralization that shapes the state form (Stein, 1994). Earle (1997) argues that we cannot assume a priori that the state or the elite is the sole or even dominant economic actor, and that the economic strategies of most non-state sectors or groups may differ from those of state institutions and their constituents. Sinopoli's (1998) study of the historically documented fourteenth through sixteenth century A.D. Hindu empire of Vijayanagara in southern India conducted a comparative analysis of horses, weapons, luxury textiles, agriculture, and utilitarian craft production. The result shows significant differences in the extent of state control and, by implication, in the involvement of nonstate sectors in these activities. Furthermore, there is some support for research into the role of non-elite groups in shaping state society. Reinhart's (2018) examination of the behavior of general craftsmen in Yanshi, China, illustrates that not only political forces drove the development of urbanization, but also ordinary artisans were actively involved in the shaping of socioeconomics, ideology, etc. Thus, the differentiation of society at different levels and the complexity of the interconnectedness of different groups are dynamic features of state society.

In summary, the formation of the state can be seen as a social stage with high level of social complexity. The early state is a transitional stage from pre-stage society to the

state society. Its material and cultural characteristics may have been highly similar to those of the previous chiefdom societies. The social structure of early state had already developed a tendency to be complex and had strong forces to maintain the integration of the whole society. The increasing power in the political structure, the stable and institutionalized economy privilege and the new sense of shared community culture are the focus for archaeologists to study the early state, rather than simply judging and examining material criterias(Figure 1).

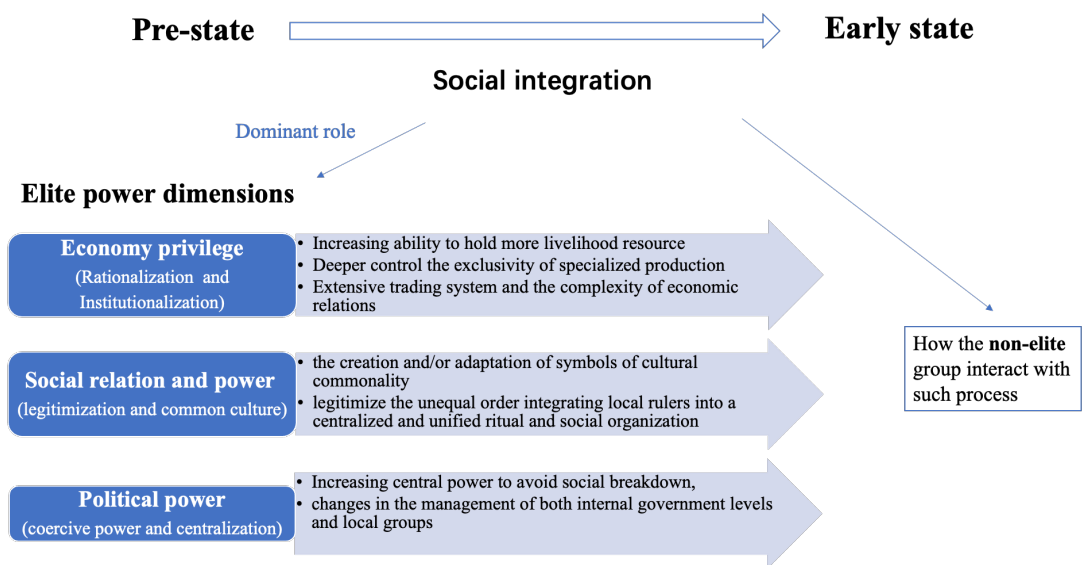


Figure 1 The change from the pre-state to the early state society

2.2.3 The trajectory from Neolithic to the early state of China

Chinese archaeology has been influenced by Marxism on the origin of the state in last century. Traditional ideas have used two criteria to judge the state: the division of nationals into regions and the overriding society of public rights. However, subsequent in-depth research revealed that the Chinese blood organization and structure played a consistent role in political life, even during the Shang and Zhou periods, so the above criteria were modified: the existence of classes and the establishment of public power. At the same time influenced by ancient legends, attempts were made in using legends such as Shangyu (上虞), Xia(夏), etc. to correspond to the archaeological culture and to corroborate the origin of the early state (Liu and Xu, 2007).

The critical changes happened in the late 1980s. Su Bingqi's examination of prehistoric Chinese society and the theory of regional types enriched the theory on the origin of Chinese states and civilizations (1987, 1990,1997). He argues that a long process of Chinese state formation was followed by a trajectory of Guguo-Fangguo-Diguo(古国-方国-帝国).Following this, Yan(1997, 2009) argues that the "Guguo," developed in most parts of the Yellow River basin during the Longshan era, is consistent with the concept of simple chiefdoms and complex chiefdoms in the evolutionary model mentioned above. Erlitou, on the other hand, represents the situation of "Fangguo" and advocates the use of the term "Wangguo" (Zhang, 1997) instead of "Fangguo." Then Diguo refers to the empires after the Qin dynasty. In the framework of Su and Yan's discussion, Zhang (2001,2014)summarized the specific connotations of the trilogy model and discussed the features and judgments of the early Chinese archaeological context. He believes that the Guguo period can be divided into two stages: the Longshan period and the so-called Yao-Shun period (late Neolithic and early Bronze Age). The Wangguo period began with the Erlitou period and was divided into three dynasties: the Xia, Shang, and Western Zhou. Thirdly, the "Diguo period" refers to the beginning of the Qin and Han dynasties, while the Eastern Zhou is roughly regarded as a transitional period from Wangguo to Diguo. He also outlined six characteristics of the formation of states in China(Table 2). Such an argument has been widely applied in the study of Chinese civilizations and early states.

The above model is similar to the evolutionism theory proposed by Service and other western researchers, and it incorporates ancient historical legends. It is not hard to find that the Wangguo period refers to the early state period compared with the evolutionary theory. The characteristics of Wangguo are similar to the criteria in the judgment of the early state, including social differentiation, settlement differentiation, urbanization, military power, centralized professional government, and the relationship between political and divine power. Besides that, the model also proposes the important role of kinship power and the possible existence of polycentric features in Chinese archaeology.

Table 2 The information of the early state in China

Criteria of the state	Zhang(1997,2001,2014)	Miyamoto (2007)
Social organization	The clan organization was loosened. The patriarchal family became the basic unit of society linking monogamous families; different families were clearly differentiated in terms of power, wealth, and status.	Highly stratified society political central urbanization
economy	the division of labor and social work spread among families,	craft specialization (highly specialized craftsmen group) ;
political	The development of rituals and the military made the specialized people powerful in society, and those who held divine and royal power became the masters of the state apparatus.	central government's political and economic system: the acquisition of external resources and the monopoly of the production of valuables, forming the tribute system over a wide area;
Ideology	kingship and divine power were equally co-existing.	
others	existence of multiple centers	

Further, Liu and Chen specifically explain the formation of early China in terms of multiple perspectives from the entire society (2012), arguing that Erlitou was an early Chinese state. It has a centralized political entity controlling a large geographical area through different levels of local administrative centers. They also summarized the basic features of the early state based on Erlitou culture: 1) the settlement's four-tier stratification: from the coexistence of multiple competing wholes to the formation of a large central master with attached local groups; 2) the central government's political

and economic system: the acquisition of external resources and the monopoly of the production of valuables, forming the tribute system over a wide area; 3) the regime's and society's continuous integration; 4) the maturing of urbanization; 5) the establishment of the military. They made a beneficial attempt to critically apply many European and American theories to the research on Chinese state formation. Furthermore, Jaang (2022) specializes in the formation process of Erlitou society from the perspective of social integration. She claims that the trajectory has seen a shift from polycentric to monocentric in settlement patterns as well as economic and political systems. The research represented by the above scholars jumped beyond the previous obsession with evolutionary models and paid more attention to the characteristics of the early Chinese state society itself and how it formed and functioned.

Archaeologists from other countries have also contributed their views and summaries to the study on Chinese state formation with Chinese archaeological evidence. Miyamoto (2007) presents the relative criteria that compound the practice of Chinese archaeology: 1) Highly stratified society; 2) political central urbanization; 3) craft specialization (highly specialized craftsmen group); 4) ritualization of mortuary and sacrifice activities; 5) legitimization of central-local relations; and 6) integration of religion and ideology. Furthermore, Shelach and Yitzhak (2014) argue, from a long-term perspective, that the complexity of Chinese society proceeded from political integration, a complex socio-economic system, and religious power in many ways. The early state in China is the result of two rapid transformations, from the unstable regional pre-states to the rapid emergence of a supraregional state.

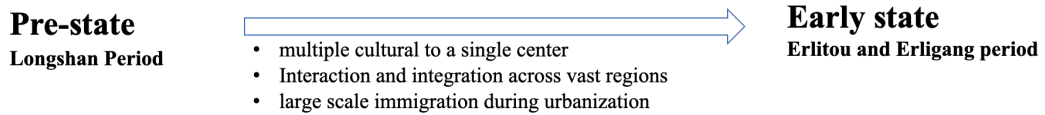
Based on the above perspectives on the early Chinese state, we understand the unique trajectory of early state formation in China. In addition to the similarities with other civilizations around the world, the first and most obvious is the unique process of early state formation is a trajectory from multiple cultural centers in the Longshan period to a single center in the Erlitou period with interaction and integration across vast regions. From the Longshan period to the Erlitou and Erligang period, the number of settlements in the Central Plains declined sharply (Liu, 2005; Liu and Chen, 2012). Large-scale settlement centers and multiple competing polities can be found coexisting

in different regions in the Longshan period, such as the Taosi site in the Linfen basin, the Yinjiacheng site in Shandong, and the Shimao site in Shaanxi, but in the Erlitou period, only one super-center of settlement existed in a wide area, forming a system of large centers dominating multiple small centers and villages (Su, 1987; Liu, 2005). This highlights the inevitability of social integration in the early Chinese state. In addition, the family-clan group established in political rights and blood-based social and power organizations did not withdraw from society even during the state period, which is consistent with the general pattern of early state formation (Zhang, 2001; Liu and Chen, 2002).

In this pattern of development, the earliest state leader: the Erlitou and Erligang elite also played a dominant function in the process of social integration (Figure 2). In economy, the Erlitou and Erligang elite had a monopoly on important resource. The most obvious was the control of vital raw materials and the production and distribution of luxury artifacts (Underhill, 2002; Yan, 2009). The Erlitou elite is believed to have formed a tribute economy system, centered on the Erlitou site, and established control of the other regional central settlements as strongholds outside the central site to obtain key raw materials such as salt and copper (Liu, 2005). They also formed so-called specialized workshops to produce turquoise and bronze around the palace area, strictly controlling the production and distribution, etc (Miyamoto, 2005; Xu, 2015). In terms of political power, as mentioned above, the emergence of the early state was accompanied by the coexistence of several competing polities to the existence of a single central power. On a wide territory, top-level burials exist only at the central Erlitou site, with sub-elite burials at the local centres, creating a sequence of burial hierarchies with Erlitou at the top and decreasing levels outside the centre (Li, 2005). This burial pattern illustrates the strong control of the central power over a wide area and its ability to integrate the wider society and to coordinate central and local relations. Specialized divisions inside the power structure also emerged within the center Erlitou, with palace areas separated by walls reflecting the monopoly and exclusivity of central power. and the palace complex could also be regarded as one of the material and cultural symbols of state power (Chen, 2007; Liu and Chen, 2012), and

the elite burials that were within the Erlitou site also had clear differences in high and low ranks and were assigned different identity markers to demonstrate the divisions within the ruling class(Li, 2005). The acquisition of social power and the integration of different groups relied on the above power, forming another characteristic of the early Chinese state. The time from the Longshan period to Erlitou witnessed a shift from multiple centers to a single center and underwent a distinct urbanization process, with numerous migrants concentrating in urban centers, creating a new social ecology where, although kinship ties did not completely withdraw from social organization, new social relations would also constantly impact the principle of social organization based on blood ties(Liu, 2005). Diverse groups of people gathered in urban centers. In the face of this diversity of people, the establishment of common social and cultural symbols is necessary to stabilize society, such as constant rituals, feasting, symbolic architecture, etc(Li, 2006). Cultural commonality was especially important in the integration of outwardly distant settlements as well (Qin, 2019; 2002). Faced with an unprecedented sphere of control, Erlitou central-local relations transcended the Longshan period by kinship affinity, but rather prestige products conferred prestige on those who could perform rituals and maintain community symbols, thus legitimizing the unequal order of those who became managers of local settlement centers and integrating local rulers into a central unified ritual and social organization. The trend toward stylized monolithic external pottery from the Erlitou period to the Erligang period confirms the gradual spread of this common cultural system, and the appearance of similar precious craft items such as turquoise and pottery drinking vessels far beyond the central Erlitou site, all driven by a strong integrating power behind them(Qin, 2019), thus completing the unification of a common political and cultural system from the center to the local level.

These dimensions of integration intertwined to form the early Chinese state, especially in terms of political structure and central authority, which began in the Erlitou period and deepened in the subsequent Erligang stage, constituting a particular path for the formation of the early Chinese state.



Social integration ability : extremely important

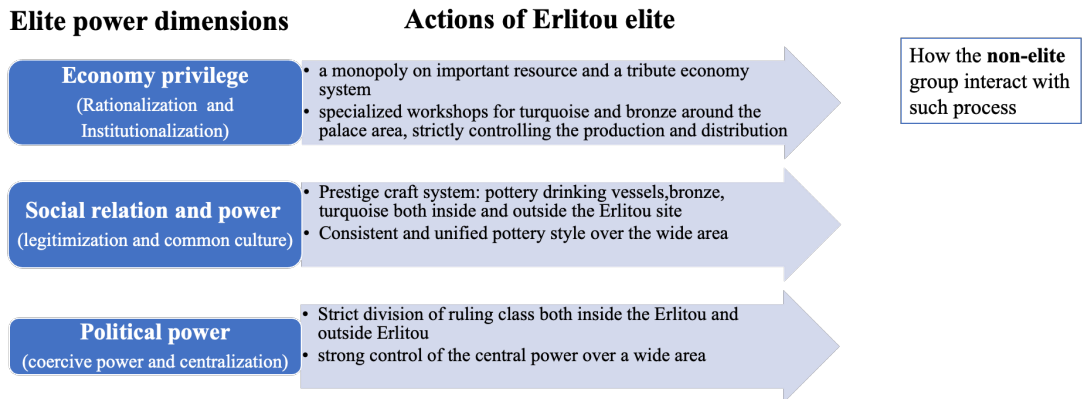


Figure 2 The change from the pre-state to the early state society in China

2.3 Craft specialization and pottery production

The degree and form of specialization of craft production is considered one of the most important indicators of social complexity and exploring the relationship between craft production and social change has become an important topic of craft archaeology. Craft specialization research contributes to a better understanding of ancient societies' social organization systems, operational mechanisms, and causes of change, as well as state formation and development and socio-political relations. In addition to the relationship with political economy, craft specialization can also effectively reveal the economic system related to daily life. Therefore, the study of craft specialization can contribute to explaining changes at all levels of society in a comprehensive manner.

2.3.1 Craft specialization: definition and typological studies

Many archaeologists have proposed their own definitions of specialization. For example, Evans (1978) summarized four key elements for defining the term, which are: few producers, time investment, absence of agriculture, and a reliance on exchange. Later, Costin (1991) defined it as a resolvable, regular, permanent, and possibly

institutionalized production system in which the producer obtains at least part of their income from the exchange. The consumer relies on the specialists to obtain their own products that they do not produce. This kind of definition is most widely cited by relevant research (Shager and Thomas, 1983; Kerner, 2010). Such arguments stress the relationship between producers, consumers, and products or services. Besides this, other archaeologists propose a different perspective to understand pottery specialization. Santley et al. (1989) define craft specialization as a form of activity segregation in which particular goods are produced for exchange by specialists at sites called workshops. They pay more attention to the organizational units than the motivation for production. In fact, the key to examining specialization is the surplus of the products. Whether there is a so-called "workshop" or not, even if the production unit is household-based, as long as there is production of certain products for exchange, specialization is where craft producers have gone beyond the scope of self-sufficiency and been separated from involvement in agricultural labor to become involved in an independent economic activity. Based on this idea, the basic definition of pottery specialization is that potters tend to produce more pottery than they need in their daily lives and use the surplus for exchange.

Many archaeologists employed modes or types of production organization and specialization during the 1970s and 1990s to define and categorize the organization of craft production. By comparing differences in the frequency of production, labor input, worker identity, degree of labor division, amount of time and material invested, and variation in raw materials and products, many archaeologists have proposed a number of models of the evolution of production organizations (Rice, 1987; Sinopoli, 1998; Costin, 1991; Pool, 1992) (Table 3). Among them, Van der Leeuw's (1977) and Costin's (1991) models are the most widely discussed and cited (Table 1). Van der Leeuw divided the modes into household production, household industry, individual industry, workshop industry, village industry, and large-scale industry. He gives detailed criteria for judging the various elements in the pottery production. Although he has offered archeological and ethnographic examples, there are some flaws in the division of this mode in that it mainly considers the scale and intensity of the production, but the social

context of production has been ignored. In a stratified society, the elite could actively intervene in ceramic production (Brumfiel and Earle, 1987; Clark and Parry, 1990; Schortman and Urban, 2004), and the results of such control may be diverse based on political agency and specific cultural context (Inomata, 2001; Lass, 2008). Therefore, the models above make it hard to explain such varied organization. On the other hand, Costin's pattern (1991) takes a more systemic approach, starting with a discussion of four parameters to describe the organization: context, concentration, scale, and intensity, which have also been similarly discussed by Pool (1992). She also emphasizes the concept of production specialization. Costin has classified the eight possible modes of production specialization based on the parameters. Such a pattern has considered the many possible forms of organization resulting from the intervention of political power or the pursuit of economic profits. It is more comprehensive in explaining the possible composition of production.

Table 3 . Van der Leeuw(1977) and Costin' s (1991) typology of production organization

Van der Leeuw(1977)			Costin(1991)				
Modes	Scale	Intensity	Modes	Context	Concentration	Scale	intensity
Household production	Small, one person	Part time	Individual specialization	Independent	Dispersed	Kin-based	Part or full time
Individual industry	Small, one person	Full time	Dispersed workshop	Independent	Dispersed	Labor	Full time
Household industry	Small,one or a few people	Part time	Community specialization	Independent	Nucleated	Kin-based	Part or full time
Workshop industry	Relative large, some people	Full time	Nucleated workshops	Independent	Nucleated	Labor	Full time
			Dispersed corvee	Attached	Dispersed	Labor or Kin-based	Part time

Village industry	Relative large, some people	Part or full time	Individual retainer	Attached	?	Kin-based?	Full time
Large-scale industry	Large, many people	Part time	Nucleated corvee	Attached	Nucleated	Labor	Part time
			Retainer workshop	Attached	Nucleated	Labor	Full time

Though such typological research has been questioned by later researchers (Duistermaat, 2016), the study of modeled production organizations has been able to provide paradigmatic references to explain most of the characteristics of ancient production organizations. Some researchers have argued that change in production organizations is a dynamic process. Arbitrarily dividing production organizations into different models is dangerous, and the boundary between the models is difficult to define (Sinopoli, 2003; Arnold, 2008). Costin (2005) is also mentioned later in their study about the dynamics of organizational model change. Furthermore, in cross-cultural studies, the patterns summarized from part of the archaeological data are criticized as being insufficient to explain the diversity of production organizations (Duistermaat, 2016). It is true that it is inappropriate to apply fixed models to different cultural contexts. However, an examination based on such a framework can enable the researcher to grasp the basic principles and essential features of production organization in this complex archaeological practice. In particular, compared to ethnographic materials, archaeological materials are poorly preserved, and archaeologists do not usually observe the characteristics of all aspects of production (Mill and Crown, 1995), so the models have theoretical implications for an explanatory framework. In this study, the typological study on craft specialization provides comparative criteria for identifying the different levels of specialization that exist in different societies, while production systems and forms of specialization, as well as the interconnections between the various variables of production, will be discussed in relation to specific social practices and context.

2.3.2 Craft specialization, social complexity, and the early state

A Craft specialization and social complexity

The relationship between craft specialization and social complexity is complex and multilayered. At the stage of state formation, with the increase of political power and the need to integrate society, some special crafts as material carriers of power and common consciousness were certainly subject to the increased control of the aristocracy thus leading to a deepening specialization. The interconnections between craft specialization, the rise of societal complexity, and political administration have been highlighted and studied from numerous perspectives (Childe, 1950; Brumfiel and Earle, 1987; Clark and Parry, 1991). Craft specialization was a method for the elite to control scarce resources to show its status and consolidate its dominance in the previous evolutionist model, and it is a method for the elite to control scarce resources to show its status and consolidate its dominance (Rice, 1987). Similarly, in Earle's political model in the discussion about craft specialization, the specialized craft production of prestige goods is dedicated to the creation of social inequality, showing its authority by creating new institutions; monopolies are a kind of elite control over the realization of economic power (Brumfiel and Earle, 1987). Such behavior could be considered a result as well as a strategy to achieve political centralization, a necessary path in the trajectory of early state formation (Miyamoto, 2005). In addition, the formation of the state and the enhancement of political power in ancient societies also required the realization of ideological control, which is usually disseminated and controlled through public ritual activities and ritual symbolic objects, which play the role of the so-called ritual system, so that the elite's control over such ritual products could also promote increased specialization.

This deepening of specialization with the intervention of the elite took many forms. The permanent sponsorship of craftsmen, or "attached specialization," is regarded as the most traditional way for elites to establish control over the production of prestige items (Costin, 1991; Costin and Hagstrum, 1995; Earle et al., 1998).

According to Costin's craft specialization investigations (1991; 2001; 2005), "attached specialization" is typically considered to be concentrated and intensive in production, with limited raw resources and advanced technologies (D'altroy and Earle, 1985; Costin, 1991; Junker, 1999).

However, as more researchers discovered that intensive attached organization was not a common phenomenon in the prehistoric period or even in the early state period (Arnold and Munns, 1994; Costin, 2001; Rochette, 2009), under the new paradigm of state formation research, archaeologists have also become more progressive and historically oriented in refining the study of control from the elite (Stein, 2001). More emphasis has been placed on how the elite participated in craft production and in what contexts they were involved. Furthermore, a growing number of studies have revealed a variety of actions in the elite's control of such goods. As a result, the relationship between modes and levels of production specialization and political economy is complex, and elite strategy and agency should be given more consideration.

The elite would constantly adjust the type and degree of their involvement in production (Hirth, 2009). For example, in Hawaiian chiefdoms, the craft goods that were very important to the elite were centrally and intensively controlled, while other handicrafts were ordered from the household without direct control from the elite. How and to what extent craft specialization was controlled varied according to the nature of the product and its importance to the elite (Lass, 2008). Therefore, the use of different pottery and its social symbolic significance were also the main factors influencing the elite's participation in controlling the craft production.

Furthermore, the heterogeneous character of the state and the focus on non-elite groups reveal that the political economy is multi-centered and diverse, and it is a complex entity that evolves in response to many political processes and forms in different societies. As a result, the elite's political strategy and ceramic production may be complex if they exist in multiple political and economic forms (Schotman and Urban, 2004). There are many different socio-economic groups, and these groups can work together in the political economy. In contrast to general acknowledgement, the ordinary household has also been actively involved in the production of prestige ceramics. The

domestic production of wealth items in the Middle Motagua Valley and Mesoamerica shows a more complicated production structure that combines ordinary people and the elite (Inomata, 2001; Hirth, 2009; for other societies, also see Costin and Hagstrum, 1995; Underhill, 1996; Wright, 1998). An increasing number of researchers have realized the importance of examining the diversity of ceramic production in cross-cultural research.

Thus, how craft specialization produced changes in state formation should not only be considered in terms of a single form of total control and attached, but the change in specialization should be judged and studied in relation to the attributes of craft products in society, political strategies of the aristocracy, rather than simply examining changes from one model to another model. It is also worth paying attention to the fact that the existence of specialization does not necessarily mean that a state has been formed. The use of prestige wealth and its redistribution, which constituted the wealth privileges of chiefs, also existed in chiefdom societies (Earle, 2002). Thus craft specialization is not the only privilege of the state leader, and in some societies the level of craft specialization may not change significantly even after entering a state society, and there will not be full-time subordinate artisans, etc. Therefore, a single paradigmatic or typological change is not sufficient to explain scientifically the complex relationship between early state formation and specialization.

In contrast to the chiefdom societies, along with the formation of the early state, the examination of specialization should focus on the extent to which artisans were controlled by the elite, what forms and ways of control were changed compared to the previous non-state societies, and what special integration strategies and cultural characteristics of the early state were reflected in the control of craft products. These possible individual differences in production specialization under the control or participation of the elite, which are key to explaining the particular trajectory of state creation and social complexity, should be carefully analyzed in the context of different social contexts and the particular trajectories of state formation.

On the other hand, besides the scope of political economy, state formation and social complexity also encompass urbanization and the horizontal division of labor in

the general economic system. Craft specialization is also closely related to the organization of the social economy outside of elite control. In this case, specialized production is a state of production driven by economic interests in order to meet the needs of a growing population under conditions of uneven distribution of resources and technologies (Arnold, 2008; Costin, 1991). This situation could be divided into active and passive specializations. Passivity is primarily due to poor farming environmental conditions, and potters were forced to choose specialized craft production for exchange in order to survive (Harry, 2005). The active one is more often discussed as being due to the increase in population. People specialize in production to meet the demand for increased production efficiency and output, as well as to meet the demand from an expanding population. With the increase in population and social complexity, the demand for various craft production has increased, stimulating the expansion of production and the level of specialization (Arnold and Munns, 1994). Furthermore, with the development of urbanization, the urban center, in addition to being the location of power institutions and ritual activities, also began to become an attraction for various craftsmen to settle and produce crafts and to supply a large demand from the "citizens," contributing to the increasing level of specialization (Stein, 2001). Such aggregation occurred in ancient China at the Erlitou site (Liu, 2009) and in ancient Mesopotamia at the Leilan site (Blackman et al., 1993). Such social complexity and craft specialization processes were mutually reinforcing.

In summary, with the increase of the dominant role of central power in the economy, political structure, and cultural patterns during the formation of the early state and the increase of social groups and complex relations during the urbanization process, the degree of craft specialization was likely to increase, both in terms of elite control of luxury goods and general goods. However, due to the diversity of trajectories of state creation and the complexity of motivations, especially in the early state stage, when the characteristics of state society were in transition, then the production of craft specialization may not correspond exactly to the development of social structures, and the degree of deepening of specialization may vary greatly from one early state to another. Therefore, the relationship between craft specialization and social complexity,

especially in the early stages of state formation, needs to be systematically examined in the specific social context, including the types, practical functions, and social functions of the products, as well as the specific social-natural environment and specific political strategies.

B Pottery specialization and the early state in China

Pottery production has a close relation to the social changes. Pottery is one of the important material carriers of human culture and society (Rice, 1987; Roux, 2019). It is made in various cultures and societies around the world. Its quality is easy to preserve and it is durable over time and widespread worldwide (Anold, 1988). These characteristics have made pottery production widely studied worldwide. Many ethnoarchaeologies also provide important references for the study of pottery production (Costin, 2000). Pottery in ancient societies had both practical and symbolic social functions. Pottery, as a necessity of human life, may not only represent a specific cultural style to some extent, but their production process and organization may also reflect the degree of labor division and economic situation (Roux, 2016; 2019). Pottery, as a symbol of social significance, like other luxury handicrafts, could reflect social stratification and political economy to a certain extent. The pottery production in Peru early state had a close relation to the religious. The elite legally controlled the pottery used in burials and ceremonies to demonstrate power, and mass production was carried out using molds (Costin and Hagstrum, 1995). The elite of the Harappan civilization of the Indus Valley demonstrated political power by painting special designs on pottery and used it for long-distance distribution (Miller, 2007).

However, the specialization of pottery shows a higher plasticity or flexibility to the social changes than other precious handicrafts such as bronze, jade, iron etc. Compared to other precious handicrafts such as jade and turquoise, its production technology requirements and raw materials were relatively easy to obtain (Li, 2017; Montana, 2016), which may have led to different strategies of control by the elite. There is a possibility that the production of luxury pottery may be different from other refined

craft items. Therefore, the special dual function of pottery in the ancient world is suitable for the examination of the full range of production activities during the formation of the state, containing both normal use scenes for ordinary people and scenes of use by the elite and ritual activities. At the same time, the relatively accessible nature of pottery raw materials and technology also made it more likely that non-elite groups would be involved in the political economy, making it easier to clarify the flexible political and economic strategies of the elite and the hierarchy of social organization in state society.

During the formation of the early Chinese state, as shown above, the economic exclusivity of political wealth, social integration, and the unification of a common culture across a wide area revealed its special cultural characteristics and path of state development. In such conditions, the establishment of the prestige goods ritual system contributed to promoting the unification of political rights and religious systems in the wide area (Xu, 2015). The hierarchical differences in luxury burial objects show that the early Chinese state elite developed a ritual system represented by bronze and jade assemblages for establishing state power authority over central elite groups and local groups, as well as for important ritual activities (Liu, 1996; Miyamoto, 2005; Liu and Chen, 2012; Shelach and Yitzhak, 2014). Especially in the Shang dynasty, refined bronze vessels occupied an irreplaceable place in the maturation process of the supra-regional state. They were attached, produced, and centrally distributed by the elite and applied to the ritual religious activities of the royal ancestors as well as to external feudal integration activities (Chang, 1980; 1986).

However, debate persists about the specialization of pottery and the function of pottery production in shaping the early Chinese state. On the one hand, some scholars argue that some precious pottery, like bronze, turquoise, and jade, assumed the function of prestige wealth and, as the state formed, its specialization deepened and became increasingly subject to the centralized control of the nobility. Before the early state, precious pottery already appeared, such as the white pottery of the Dawenkou culture and the eggshell pottery of the Longshan culture in Shandong (Underhill, 2002). They were produced with very high technical requirements and were considered to have

received centralized control and production by the ruler as a material representation of chiefly power in feasting and funerary scenes (Miyamoto,1999; 2005). Thus, even before the formation of the early state, specialization in the production of prestige pottery existed. However, these pottery vessels were only used in particular cultural areas, and there was no widespread consensus that they were often one or more types of wine or food vessels, with no fixed pattern of combination (Qin, 2019). Therefore, the degree of their specialization as well as the pattern is worth further exploration. By the early state formation stage, the Erlitou culture emphasized the combination of wine vessels and the use of white pottery vessels in palace areas and elite burials to demonstrate the legitimacy of power, as well as the use of pottery vessels in remote local settlement centers, together with other artifacts such as bronze and turquoise to construct rituals, maintain and establish hierarchical relationships and a wide network of relationships (Liu, 2005; Qin,2019; 2022). Later, during the Erligang period, the specialization of pottery production developed even further, with the clear discovery of specialized workshop remains dedicated to the production of pottery such as large-mouthed Zun in central settlements, and the rural settlements specializing in the production of pottery(Qin, 2019). This shows that the level of pottery specialization was gradually increasing during the long trajectory of early Chinese state formation, and the specialization was already evident in the Erligang period.

The problem, however, is how pottery production changed from the very beginning of state formation compared to previous societies, embodying those special ties with society but ignored by the simplification control and ritual system. Although the function of prestige pottery was recognized in the Erlitou period, and as ritual symbols were theoretically supposed to be produced with a high degree of concentration and control and thus a high level of specialization, but the evidence of such argument is not clear. No centralized workshops for the production of drinking vessels have been found within the Erlitou site, and white pottery is known to have been imported from the more distant Nanwa site. It does not meet the expectations of the traditional model. In what form they were involved, to what degree they were under the control of the center, and how they exercised their functions is unclear. The change of prestige pottery production

needs more explanation. On the other hand, recent research shifts toward the non-elite group in shaping the early state also further require the study of craft production beyond the elite's control and its relationship to social complexity. The traditional political economy model and top-down theory in previous research have generated much skepticism. Campbell et al. (2022) suggest that there is ample evidence of horizontal exchange and commercialization outside of the political economy framework, particularly during the period, and that the centralized redistribution system still needs more evidence to be proven. In addition, in the process of Chinese state formation, urbanization is crucial (Liu and Chen, 2012). The urban center serves as both the seat of the central government and the focal point for population gathering. Various craft workers have also been integrated into the urban area (Jaang, 2022). The production of pottery, then, has not been specifically studied in previous research in such a socially complex process.

As a result of the unique trajectory of early state formation in China, as well as increased attention to non-elite group tendencies, we must reconsider the relationship between pottery specialization and social complexity, especially in the early state formation process.

2.3.3 The summary of literature review and research questions

In the above section, I review the theories and studies related to social changes, the origin of the state, and in particular, the origin of the Chinese state. It has long been known that the process of social change is complex and diverse. A single trajectory or model does not provide a satisfactory explanation of complex social changes. Archaeologists' introduction of the concept of social complexity for analysis can explain the continuous stratification and differentiation of societies in a multidimensional way and treat the social as a dynamic, integrated unity ranging from political organizations to individuals. The same is true for the study of early state formation, where diversity and social heterogeneity have been the focus of research for several years. In the trajectory of early state formation in China, there are some

commonalities with early states in other regions, such as institutionalized central government, a large population, urbanization, common ideology, etc., but there are some specificities. The early Chinese state formation bears witness to the process from pluralistic centers to unification, and the early Chinese regime showed a strong capacity for economic-political and cultural integration over a wide area.

Then, through the review of theories craft specialization, I discussed the definition, typologies, and link to social complexity of craft specialization, especially possible relationships between specialized pottery production and early Chinese state formation. It is argued that the various socioeconomic contexts that existed during the state's formation also resulted in various changes in production specialization. The study and identification of specialization, as well as its specific link to state formation, must take into account the unique social context and interactions between various groups in society. Even though typological research provides an important explanatory framework as references, such arguments should go beyond the established models.

However, in the review, we know that there are also some research gaps in the previous literature. To begin, despite the fact that the typological and established models of explaining specialization and its relationship to have been increasingly questioned, the original models are still widely applied, including in the research of Chinese early state formation, ignoring the various ways and possibilities of change in pottery production influenced by different practices in different diverse societies. Then, in the study of Chinese early state formation, pottery production became increasingly neglected. The dual characteristics mentioned above make it possible that the link between pottery specialization and social complexity shows different features compared with other types of craft items. Therefore, a specific study on pottery production is necessary.

Based on such research gaps, I proposed the research question of my dissertation: **How did the pottery production specialization change in the process of social complexity, and how did it relate to the particular trajectory of early Chinese state formation?** As mentioned in the Literature Review on craft specialization, luxury pottery and utilitarian pottery are fundamentally different in their production logics and

norms, so a distinction between the two is inevitable in order to answer the above questions.

2.4 Conceptual framework and model building

In response to the above questions, the study begins by identifying and analyzing the changes in pottery production specialization in the formation of the early Chinese state. This part firstly discusses how to judge the pattern and degree of specialization and gives the judgment criteria comprehensively. Secondly, it establishes the relationship between the development of the early state and the changes in pottery production specialization as the research model to guide the research.

2.4.1 Identify specialization: craft landscape and standardization theory

How to identify craft specialization and what paradigm to use to describe a particular pattern of specialization has always been a matter of discussion in archaeological research. Faced with the complexities of craft specialization, which was influenced by a variety of natural and social factors, Costin (1991) proposes effective methods for assessing craft production in ancient societies, including four-dimensional parameters for assessing production and related archeological measures, including direct and indirect evidence. This section will discuss how to identify pottery production specialization and how to identify the possible link between pottery specialization and the early state from archaeological evidence based on Costin's framework (1991), including the craft landscape, standardization, and exchange modes.

2.4.1.1 Parameter to measure the degree of specialization

Faced with a variety of craft production modes in ancient society, Costin (1991) proposed four parameters to measure the degree of production specialization: context, concentration, and intensity of production, as well as how these various social dimensions can be measured using both direct and indirect measures. Costin's model

has been widely accepted and used as a way to measure craft production by the following archaeologists from both conceptual and practical perspectives (Mills and Crown, 1995). Besides Costin (1991), Pool (1992) proposed an alternative measurement theory. He identifies scale and efficiency, size of the social unit of production, segregation of activities, location of production, and variability of products as the important dimensions underlying the study of production (Table 4).

Table 4 The comparison of Costin and Pool' s parameters of production and identified archeological measures (see in Mills and Crown, 1995)

Parameter		Archaeological Measures
Costin 1991	Pool 1992	
Context (degree of vertical control over production)		Location of production tools, debris or facilities; high-status residence or administrative structures
Concentration (relative spatial organization of production)	Segregation of activities; location of production; variability of products	Relative spatial distribution of production tools debris or facilities; homogeneity or heterogeneity in assemblages' composition
Scale (size of production unit and principles of recruitment)	Size of production entity	Size of production facilities, degree of standardization in raw material preparation and finished products
Intensity (Amount produced per unit of time)	Scale, intensity, and efficiency	Number of vessels produced; range of economic activities represented; number of production steps used; standardization in raw material preparation and in finished products; degree of skill

Although they are similar in terminology and have some commonalities in archaeological measurements, Pool (1992) focuses more on the activity of production

itself, and Costin (1991) focuses more on the organization of production and the relationship with social factors. However, they both provide important indicators for measuring production activities and specialization. The two models can be combined to investigate the context of production itself and the link between production and society.

From the archaeological measures in the above models, it is clear that production specialization is mainly implied by direct and indirect evidence in archaeological practice.

2.4.1.2 Direct evidence

Direct evidence refers to production facilities, tools and related debris found in archaeological remains, which is considered as the strongest evidence of craft production especially ceramic production (Mills and Crowns, 1995). As mentioned above, it can provide valid information to reveal production characteristics and level of specialization.

Determining the physical location of production units is the first step in examining the organization of production. The judgment of pottery production location mainly depends on the location of pottery tools, equipment, or the concentration of raw materials and finished or un-finished products (eg., Russell et al., 1998). However, there are some problems with this. First, the materials are not easy to identify, and the completeness of such evidence is not high in actual archaeological excavations and research. Such a situation may mislead the judgment of the production location. Furthermore, pottery production is a very common livelihood activity in prehistoric society as a whole. The traces and evidence of pottery production are not easy to distinguish from the whole of subsistence activities (Stark, 1991). It is usually mixed with other craft production activities. Secondly, compared to other types of craft production, the tools and facilities for pottery production are not easy to preserve. It is true that the open-air firing is really hard to trace and some of the tools the potters use is made of wood or cloth (Costin, 2001), which are easily ruined. Compared with such

portable evidence, some immovable production equipment, such as water wells, pottery kilns, etc., is relatively easy to distinguish. Therefore, in this research, the kiln is the primary criterion for judging the production loci, and I will also combine it with the tools and related facilities found to make a complete examination.

After identifying the production loci, the location of pottery production is an important part of the interpretation and description of the organization of ancient pottery production (Costin, 2000). The most common goal of the studies is to figure out whether the production is domestic or non-domestic, independent or attached (Costin, 2005). Small-scale household production is generally located within a residential site and near houses, even as a part of the household landscape. Non-household production, on the other hand, is located a certain distance away from the household entity. They are even consciously isolated from the housing and daily activity areas. Such an examination is also supported by ethnoarchaeological evidence (Longcare et al., 1988; Underhill, 2002). In addition to this, centralized attached production under elite control would also show characteristics different from independent production, and they were usually located in or adjacent to areas of buildings associated with power. In Shang dynasty China, the elite tended to build up concentrated craft workshops directly within the palace area (Reinhart, 2018). Such an arrangement facilitated the control of production and the manipulation of production resources. Although the dichotomous examination received some doubt, it provides a preliminary judgment on the production of ancient pottery organizations. But judging organizational characteristics purely from the location of production is too vague and arbitrary, and does not provide a detailed account of how production was specifically organized (Santley et al., 1989). Ethnographic examples have demonstrated that even pottery production units around the same household differed significantly (Wang, 2003). This requires a more detailed judgment and inquiry. Therefore, in addition to the initial determination of the location of the production units, the results of the internal space arrangement and the relationship with the surrounding landscape need to be studied to clarify the more detailed production patterns. (Table 5)

Table 5 Archeological indicator of production organization

Evidence	Context	Concentration	Scale	Intensity
Tools and debris	Unknown	Found throughout the site vs concentrated in certain area and high uniformity	Low density vs high density	Mix with other activities tools vs exclusive pottery production tools
Location	Household vs in or near the power concentration area	Found throughout the site vs concentrated in certain area	Within the household vs separated location out of the household	Difficult to know
Inside spatial arrangement	Radom layout vs Power-related institutions and well-planned, possible management unit	No or simple arranged vs clear layout	No special arrangement within small area and mix with other activities vs large area, clear spatial arrangement for each process	Difficult to know
Relation to the surrounding landscape	Normal production landscape, normal house vs power-related buildings and specific area	Unknown	Many houses round; a part of household landscape vs isolated area and exclusive landscape only containing pottery	Difficult to know

			production	
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The dichotomy of the table only points out the characteristics in the extreme parameter case.

Firstly, the density of such evidence may represent the intensity of production as well as the degree of concentration of production. In small-scale household production, production tools tend to be more dispersed in distribution and limited in number, representing limited production capacity and efficiency (Costin, 2000). Beyond this, the proportional composition of the types of tools excavated in the area can also indicate the production types. Because the pottery tools are mixed with other tools, it is highly likely that multiple craft production activities may be carried out in the same space (Hirth, 2009). Secondly, the internal structure and spatial organization within the production complex can also provide the scale and possible intensity of production. Small-scale production and lower inputs that simply meet the needs of households do not require fine spatial planning, and production activities can often be completed entirely within the household space (Santely et al., 1989). Conversely, a fine division of labor in large-scale production requires a clear space arrangement for production. Large-scale production also requires sufficient space for storage of semi-finished and finished products (Costin, 2005). The final element is the connection between the production unit and the surrounding landscape. In addition to examining the location of production, the surrounding environment is also important. The isolation of the production environment from the surroundings alone is considered to be a characteristic of workshop specialization, while the surrounding of numerous houses is recognized as evidence of household involvement in production (Underhill, 1996). Moreover, when the production unit is surrounded by institutions of power or facilities associated with power, or by a cemetery, etc., it indicates a different composition of production compared with the normal production units, as opposed to production in the general sense of exchange (Tosi, 1984).

2.4.1.3 Indirect evidence : Standardization and differentiation

Standardization refers to the homogeneity of the crafted items. The degree of standardization is commonly involved in discussing and measuring craft specialization, including ceramic organization (Longacre et al., 1988; Stark, 1991; Blackman et al., 1993; Arnold, 2000). The specialized potters tend to have advanced technology to maintain the uniformity of the pots, and they are likely to be highly efficient to gain more profit (Costin, 1991). Based on such ideas, many studies believe that a higher degree of standardization represents a higher degree of specialization (Stark, 1991), and this relationship is supported by some ethnoarchaeological studies (Longacre et al., 1988). For example, in the process of state formation in ancient Mesopotamia, the increasing standardization implied an increased degree of pottery specialization in the context of an ancient state with enhanced control from the elite (Blackman et al., 1993). Hagstrum (1985) evaluated the gestures and morphological standardization on black-on-white ceramics from the northern Rio Grande and found evidence for a change toward greater standardization in the Classic period. In China's early state period, Qin (2019) has researched the cooking vessels from the late Erlitou period to the Erligang period. She found out the cultural style, the size, and even the decoration pattern of cooking vessels in Zhengzhou and Yanshi and witnessed the standardization trend. All of the preceding studies show that high standardization may have occurred as a result of the increasing social complexity process.

However, with further research and expanded studies in ethnoarchaeology, researchers found that the relationship between standardization and specialization in a certain social context is very complex. First of all, the standardization can be evaluated in terms of the shape of the product, the dimension of the product, the composition of raw materials, the production technique, the decoration, etc. (Stark, 1991). Reliable conclusions can only be drawn when such multiple variables all exhibit specialized characteristics. The practical and social functions may then infect the societal standardization trend. The specialization of some luxury goods that were important to

the elite was more about the refinement and diversity of the products than about the efficiency brought by standardization (Rice, 1987). So even if the production of these products is highly specialized, there may be a low level of standardization. Last, the previous standardization hypothesis was based more on ethnoarchaeology examples, where the researchers could directly observe the entire production process. But the examination of archaeological remains is not direct. Residual pottery may come from multiple production units and span a long period of time, which is called "cumulative blurring" (Blackman et al., 1993), so the standardization results are subject to numerous interferences. The absence of these considerations can lead to misinterpretation of standardization results and interfere with the examination of the relationship between standardization, specialization, and social complexity. Therefore, it is necessary to reorganize the types of standardization, the motives that may lead standardization and the specific relation between specialization and social complexity.

Standardization can be divided into two types according to different motives: non-intentional standardization and intentional standardization (Stark, 1991) (Figure 3). Non-intentional standardization, also called mechanical standardization in some studies, may be the result of mass production and high efficiency. It is more like mechanical production (Guo, 2012). In a specialization context, there would be fewer potters to produce more pottery (Costin, 1991), which means potters have a greater workload and must improve efficiency to meet the huge demand of the market. Potters also would like to gain more profit through routinizing the process of production. Costin (1991) calls this "industrialized production," reflecting cost-cutting strategies. Highly standardized pottery means that potters use limited raw materials and some standardized or stylized techniques, such as mass production or the use of molds, to ensure product consistency. In addition, standardization is closely related to production processes, potters' technical experience, degree of quality control, production efficiency, operating habits, and individual heterogeneity (Guo, 2012), all of which can directly reflect the form of organization of craft production. As a result, a careful examination of non-intentional specialization can reveal the degree of specialization. A high degree of standardization in such a context can, to some extent, represent a high degree of

specialization in certain production ranges, and the motivations behind it, such as increasing production efficiency and mass production, can also imply a deeper division of labor in the social process. On the other hand, the intentional standardization is more related to the involvement of the elite and can reflect the actions of the political class. Such production is to meet the special needs of politics or ritual and reflect the social and political functions of craft. The centralized and attached organization of production under the control of the elite, which may produce highly standardized products, also had more to do with the wishes and requirements of the elite. Some luxury goods existed with deliberate diversification in some types of goods to differentiate from the commoner and show off the status or wealth. Rice (1981) proposed a model to clarify the standardization and diversity of pottery in different states of social complexity. She tested the model with pottery from Mayan Ruins in Belize's Baton Rémy District, assuming that in a stratified society, pottery would be standardized in both prestige and unitarian contexts, but prestige pottery would be more refined and distinguished in decorations. This demonstrates that the prestige craft may have a strong specificity due to the strong exclusivity of the state's central power. This specificity was expressed in the preciousness of the raw materials, the high complexity of the craftsmanship, or the marked difference in shape from the usual products (Liu, 2003). Such deliberate differentiation is also known as another distinguishing feature of the rulers' control over handicraft production in highly complex societies. Therefore, both the high level of standardization and the high level of diversification may imply a high degree of production specialization under the control of a powerful elite. The involvement of the elite in craft production was inevitable in the formation of the early state, and, along with the maturation of social differentiation and the institutionalized division of labor among the ruling classes, the control of luxury crafts resulted in extreme standardization or diversification.

Therefore, examining the relationship between pottery standardization, specialization, and early state formation requires a separate examination of standardization under different motivations. Standardization alone does not equate with specialization, and the specific link needs to be examined by understanding the

production motives and mechanisms behind them according to product attributes. In addition, especially for prestige products, not only standardization but also differentiation between different groups needs to be examined, especially the contrast between standardization and differentiation in different usage scenarios to reflect specific political and economic strategies and thus the particularities in the production in different contexts.

Then, in addition to the types, the method of measuring standardization should be cautious. Standardization can be evaluated in terms of the external form, the composition of the raw material, the decorative pattern, the production technique, and so on. Standardization is used by most archaeologists to examine specialization due to the ability to visually quantify various attributes of the artifacts, where the concept of the coefficient of variation (CV) is introduced for quantitative comparison (Benco, 1988; Erkens and Bettinger, 2001). Generally, a higher coefficient of variation indicates a lower degree of standardization, while the opposite is true for a higher degree of standardization. CV is mostly used to examine craft dimensions and metrics. In recent years, there have been attempts to quantify the shape, raw material, and technology attributes of craft (Blackman et al., 1993) and use CV as well to compare these attributes (Wang and Marwick, 2020). Besides that, due to the cumulative blurring mentioned above, the application of CV calculations in archaeological research requires spatio-temporal grouping analysis, ensuring sample co-location and simultaneity to minimize the impact on standardization.

The relationship between the absolute value of the coefficient of variation and standardization is also highly controversial. It is generally believed that 10% or less of CV means mass production and craft specialization (Stark, 1991), or that a CV below 14% could reflect specialization based on the research on pottery in the Casa Grandes Region by Topi et al. (2018). However, such an absolute value and link to specialization has raised many questions. Because there are many factors affecting the calculation of standardization, the synchronicity of the sample cannot be guaranteed in the context of archaeological research, as in ethnography studies (Anorld, 2000). Therefore, it is unscientific to rely on absolute values of CV to determine whether archaeological

artifacts have reached a certain level of specialization. So standardization is used more for comparisons between groups, explaining possible differences in production. Thus, standardization is relative.

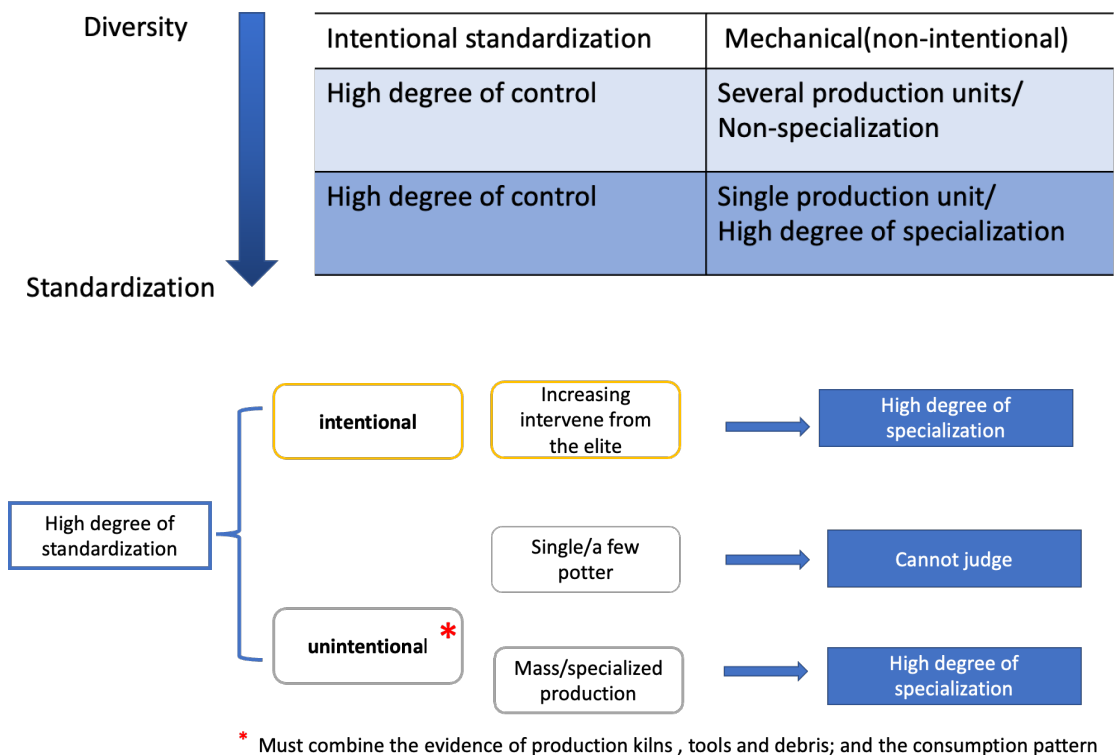


Figure 3 The explanation of standardization and specialization

2.4.1.4 Consumption and exchange pattern

In addition to the standardization theory, the consumption and exchange patterns of the crafts can be used to reflect the degree of specialization. Specialized production is essentially the separation of producers and consumers, so the existence of exchange behavior is the basis for the formation and development of specialization (Costin, 1991). Furthermore, the exchange and trade of products was an important part of the ancient craft economy, especially the exchange and trade of luxury goods, which were not only the result of craft specialization but also related to the development of social complexity. Therefore, research about the exchange of products is important for judging the level

of specialization and even the process of social complexity and the origin of the state.

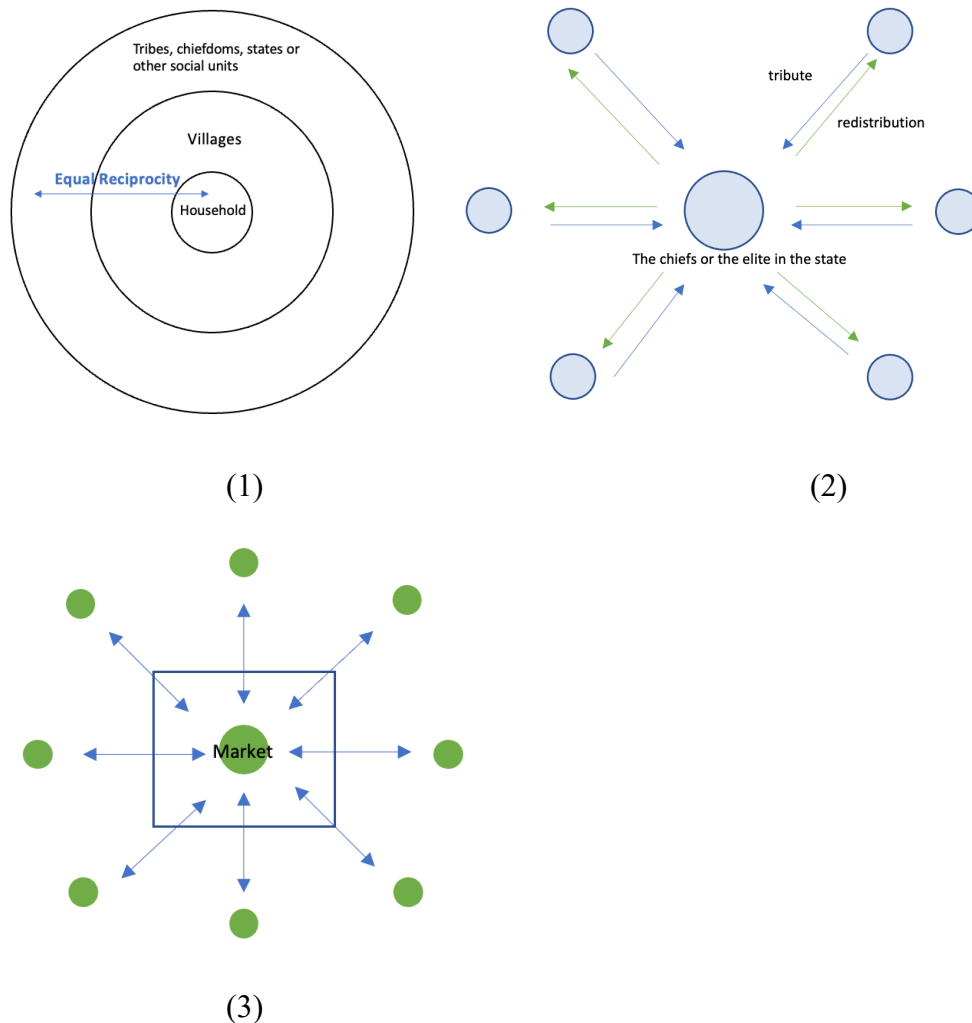


Figure 4 The exchange patterns: (1) reciprocity; (2) Redistribution; (3) Market

Both types and distances are used to examine the level of production, production specialization, and the social situation. First of all, the types of exchange are broadly divided into reciprocity, redistribution, and market exchange (Polanyi, 1957; Adam, 1974)(Figure 4). Reciprocal exchange is a transaction of equal value between two parties of equal status where there is no dominance between the two parties, and it usually takes place between acquaintances in a particular society (Polanyi, 1957). It is unstructured behavior. Redistribution, on the other hand, is the aggregation and redistribution of goods to participants through a certain organization and is usually considered a characteristic of a chiefdom or state (Friedman and Rowlands, 1977). A "market exchange" is a bargaining transaction between participants in a particular

location (Renfrew and Paul, 2007).

According to the geographical and social scope of exchange, there can be internal and external exchange. Internal exchange is a transaction within a unified social system, which can contain all three types of exchange outlined above. Depending on the function and social structure of the exchanged items, the exchange could be different. There may be specialized management organizations for prestige in a stratified society that are used to maintain social relations within the society. Utilitarian goods are typically exempt from this type of management. On the other hand, long-distance exchanges beyond the scope of the social system are often considered to be for certain prestige goods, driven by strong central power (Friedman and Rowlands, 1977). The establishment of long-distance exchange networks is generally considered one of the most important ways to maintain central power in the ancient world (Earle, 1997).

The above different types and scopes of exchange are considered to correspond to different levels of production specialization and social stages. As Costin (2005) said, exchange is an implicit part of all specialization (just as specialization is implicit in all exchange). Reciprocity is usually considered a small-scale exchange within regions, common in egalitarian societies where production specialization is nonexistent or at a low level. In contrast, redistribution is considered to be a product of vertical social differentiation, with forms of tribute and redistribution considered to be important features of chiefdoms or more complex state societies (Friedmann and Rowlands, 1977). In this case, specialized managers were needed to manage production and distribution, and this was accompanied by specialized production of refined goods under elite control (Liu, 2005). The market exchange, in contrast, was a form of exchange that gradually developed after the creation of the Asiatic state due to further economic development and changes in the original social structure (Friedman and Rowlands, 1977), and the occurrence of the market exchange also directly implies the development of craft specialization, the aim of which is to produce goods for exchange.

Although the above classical paradigm is widely used, the relationship between different exchange types and societies is much more complex. Goody (1982) argues that it is more important to examine the mechanisms of exchange together with the

social relations contained therein. The exchange could be voluntary, obligatory, or forced. The researchers should also analyze whether production is rewarded in any way, either in terms of the fulfillment of obligations to the upper level (social reward) or economic reward, so that the relationships that exist between the three types of exchange above may be more complex. He refines the social and economic ties between producers and consumers into five types: allocation within the production unit (household), gift (voluntary, no return), reciprocal exchange, the market, and obligatory transfers (e.g., tax and tribute). Such five types of exchange ties refined the social relations included in the various modes of exchange. It has added intra-household allocation and gifting to the original three categories and refined the original category of redistribution into obligatory exchange, expanding the scope and mode of behavior of exchange under elite control. This type of investigation allows for a better understanding of the dynamics and mechanisms of exchange, making it easier to analyze the level of production specialization under various exchange patterns and then comprehend the related social information, such as social organization or degree of social complexity. Costin (2005) also criticizes the fact that the discussion of the three types of exchange is loosely linked to the discussion of modes of production and social organization. It is difficult to assess the level of specialization and one-to-one connection with social formations based solely on exchange types, but also on the social-economic ties underlying the exchange behavior.

Exchange and social relations in an early state society may be complex, with various types of exchange patterns and ties. Reciprocity may exist in various aspects of society (Polany, 1957); it could exist in state society as well. More importantly, it is necessary to rethink exactly how obligation transfers, such as redistribution in political economy, operate and function in stratified societies. Redistribution was not necessarily present in all crafts in chiefdoms and state societies; for example, dolomite spade production in the Erlitou state society did not form a redistribution system but was produced at a local site (Liu and Chen, 2012) and may have entered the Erlitou center through market trade. So even though there was inequality of status in exchange, it did not necessarily take the form of redistribution or tribute. In addition, as mentioned

above, the general exchange of households was a way to enter the political economy and provide consumption for the elite without a redistributive system or a fixed market for trade. So, in a state society, obligation transfers may exist, but they are not always implemented as a form of redistribution controlled by the center, which may also involve households or local agencies. Furthermore, the market exchange was more complex than expected, and in addition to further economic and specialized development, there were also market exchanges within the countryside due to differences in the distribution of natural resources, as Arnold (1988) did in his study of the pottery-making peoples of rural Mexico, where most or all households made potter, and where large quantities of pottery could be exchanged through specific locations among specific social groups. Such markets have little relation to social organizational factors and does not respond to certain social types. As Goody (1982) proposed, both redistribution and the existence of markets may imply the existence of specialization, but the specific level of specialization and the specific links to social factors necessitate a deeper understanding of the mechanics and principles of each type of exchange in order to make a valid judgment about the social situation.

In the process of judging the exchange pattern and its relationship with the pottery specialization and state formation, first of all, the analysis of raw materials and technological or stylistic features is necessary to presume the origin of the pottery, followed by a careful analysis of the specific logistical and social mechanisms of exchange to determine the social relations that exist in the transaction.

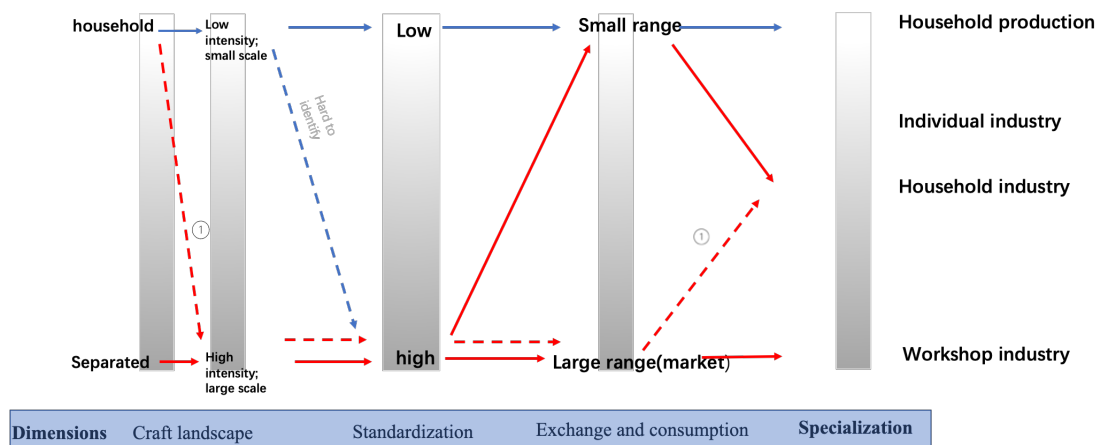
2.4.2 Summary of identifying and investigating pottery specialization

In summary, combined the arguments above, the process for determining the level of specialization is listed below (Figure 5). Because the mechanisms of forming specialization under different motives differ significantly, the judgmental approach is divided into two categories based on the criteria of the product's attributes (whether it serves elite needs or not).

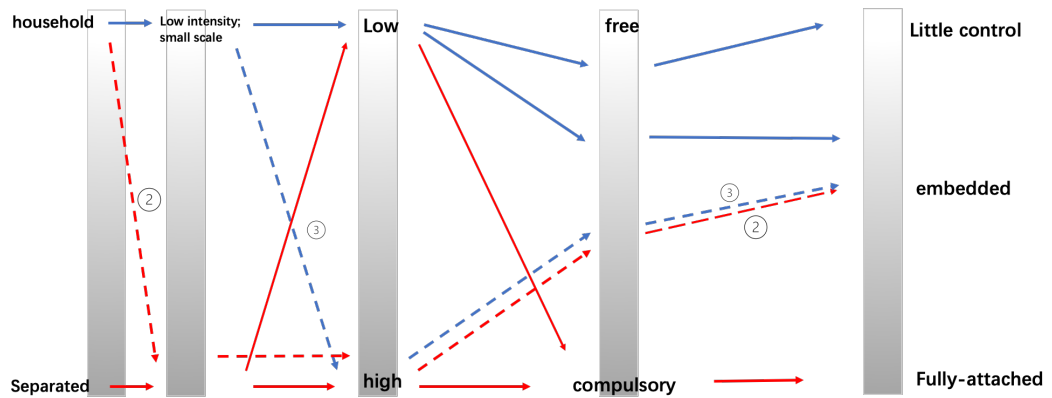
The first is the identification of specialization in common pottery, which involves

the following three dimensions: 1. the degree of separation between production units and households and the intensity of scale; 2: the degree of product specialization 3: the scope and mode of exchange and consumption. The degree of production specialization can be judged by the different situations of the above three categories. Second, handicrafts involve the scope of aristocratic control or intervention behavior. Again, the three dimensions above can be examined, differing in the degree of standardization and the manner of exchange and consumption. The deeper the aristocratic intervention will lead to a higher degree of specialization, and the degree of standardization will show two extremes, i.e., standardization as well as differentiation, which are related to the purpose and strategy of the aristocracy in using handicrafts, while there may be diverse variations in the way of transaction, and the higher the degree of specialization, the stronger the compulsion of transaction, reflecting the stronger control of the aristocracy. Since the above three dimensions do not vary synergistically, the line in the figure demonstrates the relative level of specialization reflected by the combination of different levels of the three dimensions.

Besides that, the typological terminology of Costin(1991) and Vander(1977) was used as a reference for the degree of specialization and as a speculation of possible forms. The graph therefore shows the most extreme cases or comparisons that can be made between different societies or periods.



(1)



Dimensions	Craft landscape	Standardization	Exchange and consumption	Specialization
------------	-----------------	-----------------	--------------------------	----------------

In the household context, the potters may be employed to produce luxury craft.(2) continuous (3)occasional

(2)

Figure 5 The model for judging the degree and forms of specialization (1) ordinary product (2) product serving for the elite

2.4.2 Model building

The purpose of this section is to form a model that can be used in archaeological research to show the selection of archaeological evidence, the changes in specialization, and the relationship to the emergence of early Chinese states.

2.4.2.1 Archaeological evidence selection model

The first is a model for the selection of archaeological evidence. In the 2.4.2 section, the relevant dimensions and examination methods of identifying the pottery specialization was discussed. In actual archaeological practice, a wide variety of archaeological evidence can then respond directly or indirectly to the changes of pottery specialization, allowing archaeologists to analyze specialization either quantitatively or qualitatively. As mentioned above, this evidence can be categorized as direct and indirect evidence (Costin, 1991), Figure 4 builds on this categorization to more refine the variables to be analyzed in each type of evidence.

The examination of evidence such as pottery production equipment and tools can directly reflect the scale and intensity of production methods and directly explain the

spatial organization principle of production. In addition, when examining the relationship between the location of the production unit and the surrounding landscape, the identity of the artisan can be indirectly implied, with the household range representing the artisan as a general potter. On the contrary, it may represent a special social identity. The direct evidence provides important information about the craft landscape. The pottery can be used more subtly to represent the variables of the production system. In addition to reflecting the properties of the product itself, the pottery can identify the production system by examining the composition of the clay to determine whether it is from a stable source, how difficult it is to obtain, and whether it is distinguishable. In addition, the standardization and variation in clay composition, shape and size of the pottery effectively reflects the level of specialization. The context of the pottery excavation can also indirectly elicit the corresponding consumption and exchange pattern. Therefore all of the above information is needed to be included in this study to examine the degree of specialization(Figure 7).

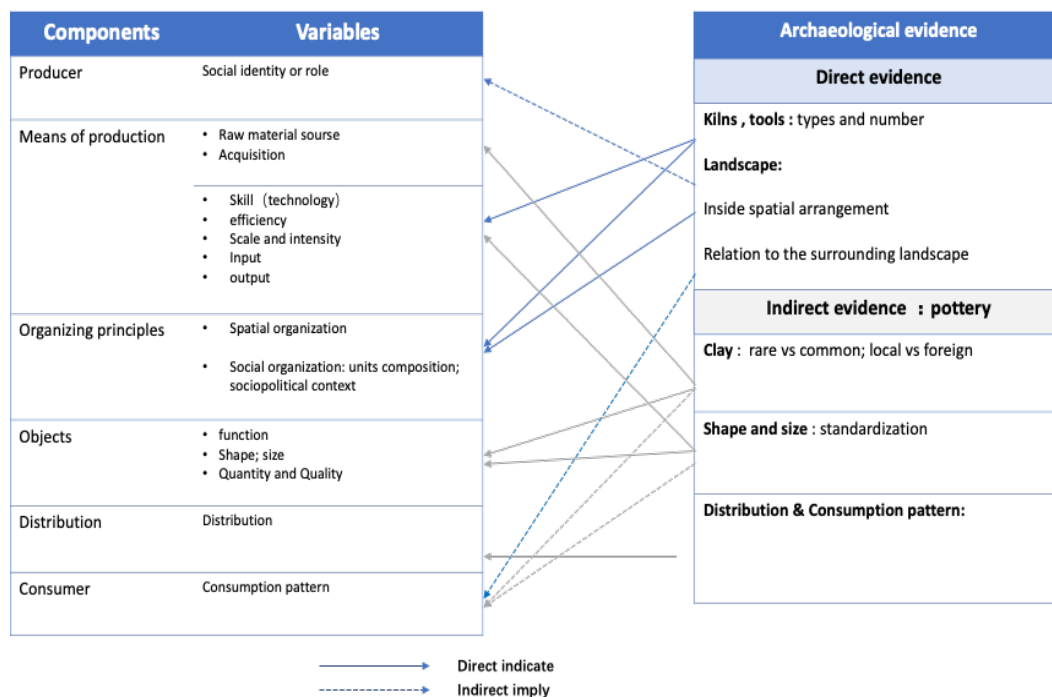


Figure 6 The list of archaeological evidence which can imply the variation of production components

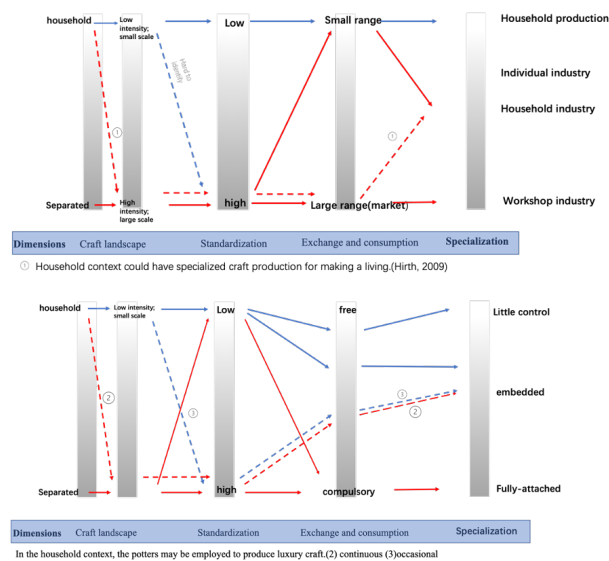


Figure 7 The archaeological evidence to investigate the pottery specialization

2.4.2.2 Archaeological evidence variation model

The second step is to establish a model to show how the evidence selected could vary during the changes of pottery specialization. Schortman and Urban (2004) go into greater detail about how variables change in response to changes in the production system, particularly in the process of social complexity (Figure 8). They place emphasis on the direction of change of the different production variables in the context of the enhanced specialization of craft industries that may exist in the process of social complexity in the political economy framework. Their model thus discusses the changes in the components of craft production as political processes centralized, differentiated, and unequal in terms of the amount of political power involved and the exclusivity of production and the identity of the artisan. It provides a valid reference model for discussing the study of pottery specialization with elite involvement.

- **1: The production tool, kilns , debris and surrounding landscape**


(to identify production context, intensity, scale)

- **2: clay composition; shape ; size**

(to identify the degree of standardization; the differentiation of pottery with different functions)

- **3: the production units and consumption context; consumption combination and number in different contexts**

(to identify the exchange and consumption pattern)




		The degree of specialization 	
Components	Variables	Continua of variation	
Producer	Social identity or role	Non-specialists; not tied to craft production	As an artisan participating in a specific craft ;(attached to or sponsored by elite patrons)
Means of production	<ul style="list-style-type: none"> • Raw material sources • Acquisition 	<ul style="list-style-type: none"> • Local; • Simple, easily mastered, require little coordinated effort 	<ul style="list-style-type: none"> • Foreign; • Complex, hard to get, need the coordinated work of many individuals.
	<ul style="list-style-type: none"> • Skill (technology) • efficiency • Scale and intensity • Input • output 	<ul style="list-style-type: none"> • Easily learned and used • Low • Few people, limited steps, little energy investment ,random production • low 	<ul style="list-style-type: none"> • Hard to learn , need considerable practice to maintain; • High for the utilitarian goods • Numerous artisans, complexly organized production steps, major energy expenditures • high
Organizing principles	<ul style="list-style-type: none"> • Spatial organization • Social organization: units composition; sociopolitical context 	<ul style="list-style-type: none"> • Dispersed or just in the household • Family • Independent of direct elite control 	<ul style="list-style-type: none"> • concentrated; separated from the household, urban centers (or aggregated near elite compounds and administrative centers) • Complex composition • Independent and elite embedded or fully attached
Objects	<ul style="list-style-type: none"> • function • Shape; size • Quantity and Quality 	<ul style="list-style-type: none"> • Daily use • Un-standardized • Relative low 	<ul style="list-style-type: none"> • Daily use plus symbolic meaning • Standardization or intentional(standardization/diverse) • High(or controlled by the elite)
Distribution	Distribution	<ul style="list-style-type: none"> • No limitation • Self-sufficient or reciprocity 	<ul style="list-style-type: none"> • Market oriented • Redistribution determined by the elite (high restrictions)
Consumer	Consumption pattern	No specific pattern	Institutionalized pattern

Figure 8 The model about how variables change in response to the specialization (summarized from Schortman and Urban, 2004)

In this framework, combined with the discussion of the discriminatory dimensions of specialization above, the variations in the evidence for pottery production can be predicted as follows (Table 6):

1. craft landscape dimension: the tools and facilities for producing pottery evolved from small numbers and locations mixed with household context to specialized production workshops with a large number of tools, centrally distributed and separated from other production areas, and the production units of prestige pottery were closely related to the authority.
2. The standardization and differentiation dimension: the change from low-standardized, common, to highly standardized, or differentiated, pottery.
3. The exchange and consumption pattern dimension: from a small range of reciprocal random transactions to a large range of fixed tribute and market transactions, the distance from the place of origin to the place of consumption (geographical distance and social distance) from near to far, consumption scenarios and combinations from ordinary random consumption, only to meet life, to fixed polarization.

Table 6 Archaeological evidence variation model applied in this study

Dimensions	Evidence variation		
Craft landscape		Household-based → Professional, independent	
	<ul style="list-style-type: none"> • <i>Kilns, tools</i> • <i>Location</i> • <i>Surroundings</i> 	A few, scattered No plan, within the household context Mix with household and other activities	Large number, concentrated Well-plan, separate space Independent (related to authority)
Standardization and differentiation		Unstandardized, no differentiation → Highly standardized/ highly differentiated	
	<ul style="list-style-type: none"> • <i>Clay</i> • <i>shape</i> • <i>Size</i> 	Less standardized, local Less standardized Less standardized	Higher standardized, highly deafferentiation between ordinary and prestige Higher standardized or highly diverse Higher standardized or highly diverse
Exchange and consumption pattern		Reciprocal random trading → Fixed tribute or market	
		Ordinary and redistribution → Ordinary consumption and stable/ institutionalized redistribution	
	Place of production and consumption	Small range;	Wide range
	Consumption combination	No stable combination	Stable combination following social status
Consumption context	Ordinary and mortuary	Ordinary, mortuary and center-local with more differentiation	

2.4.2.3 The final model

In the final stage of model building, the complexity and diversity of changes in specialization and the trajectory of early state formation in China need to be explained in an integrated model. State formation could be accompanied by a degree of increased craft specialization, both in precious and everyday pottery, and has been corroborated by multiple early experiences of early state formation. It is possible that the degree of change in specialization was not sufficiently pronounced during the early state stage and that there may not have been a dramatic change from one pattern to another, but the changing trends in social integration and urbanization reflected in its specialization can be explained by a refined analysis of the production variables mentioned above. The purpose of this study is not to make a purely linear one-to-one correspondence between state formation and specialization patterns. Rather, the hope is to explore how specialization has changed in which dimensions in terms of the possibilities for variable change offered by the model, and thus to explore the motivations behind it and consider how it is related to early Chinese state formation.

As mentioned in 2.2.2 above, the process of early Chinese state formation was a

process of institutionalization and centralization of social integration on a broad scale, including the economic privileges of the elite, the further centralization of political power, and the shaping of cultural commonalities on a wide territory. In addition, the social groups and the complexity of their relationships also increased as urbanization proceeded. Thus, pottery, as a necessity of everyday life, was also a material representation of the multidimensional components of society, and its role and response in social integration could change with the process of state formation (Figure 9). As one of the material symbols of socio-political power, prestige pottery was bound to play an important role in embodying the economic dominance of the elite as well as shaping their legitimate identity, and thus the control of the elite was expected to increase. In addition, driven by the need to establish political and cultural legitimacy and identity on a broad scale, the power to shape their meaning and production was tightly controlled among the elite, leading to a rapid deepening of specialization. The main manifestations of this in archaeological evidence are independence on the production landscape, increased standardization and exclusivity of products, and restriction and exclusivity of forms of exchange and redistribution. On the other hand, urbanization brought new migrants who developed from the original peasants into new groups of society with various identities, including professional potters, to adapt to the new urban social context and to meet the demand for pottery in the urban landscape, so that pottery production would have deepened to a certain extent. The main manifestations of this in the archaeological evidence are the expansion of pottery production and scale, the increase in standardization, and the expansion of the scope of exchange.

This model integrates the complex processes of state formation, social organization, and pottery production specialization and gives ideas for possible explanations and corroboration of the changing archaeological evidence. It enables a comprehensive examination of social relations and social trends hidden in the early state formation stage due to the lack of obvious social characteristics in some states and also provides the possibility of materializing the examination of early state formation. It should be noted that such relationships are theoretical evidence of production and factor changes in an ideal state, and in practical application, not all variables may

change simultaneously, or specialization may produce drastic changes in one dimension while another dimension remains unchanged due to the resilience of the old society, so the model needs to remain dynamic in its examination. This non-synchronous change can also be applied to explain more about the special relationship of various social elements in state formation to explain the specificity and diversity of state formation.

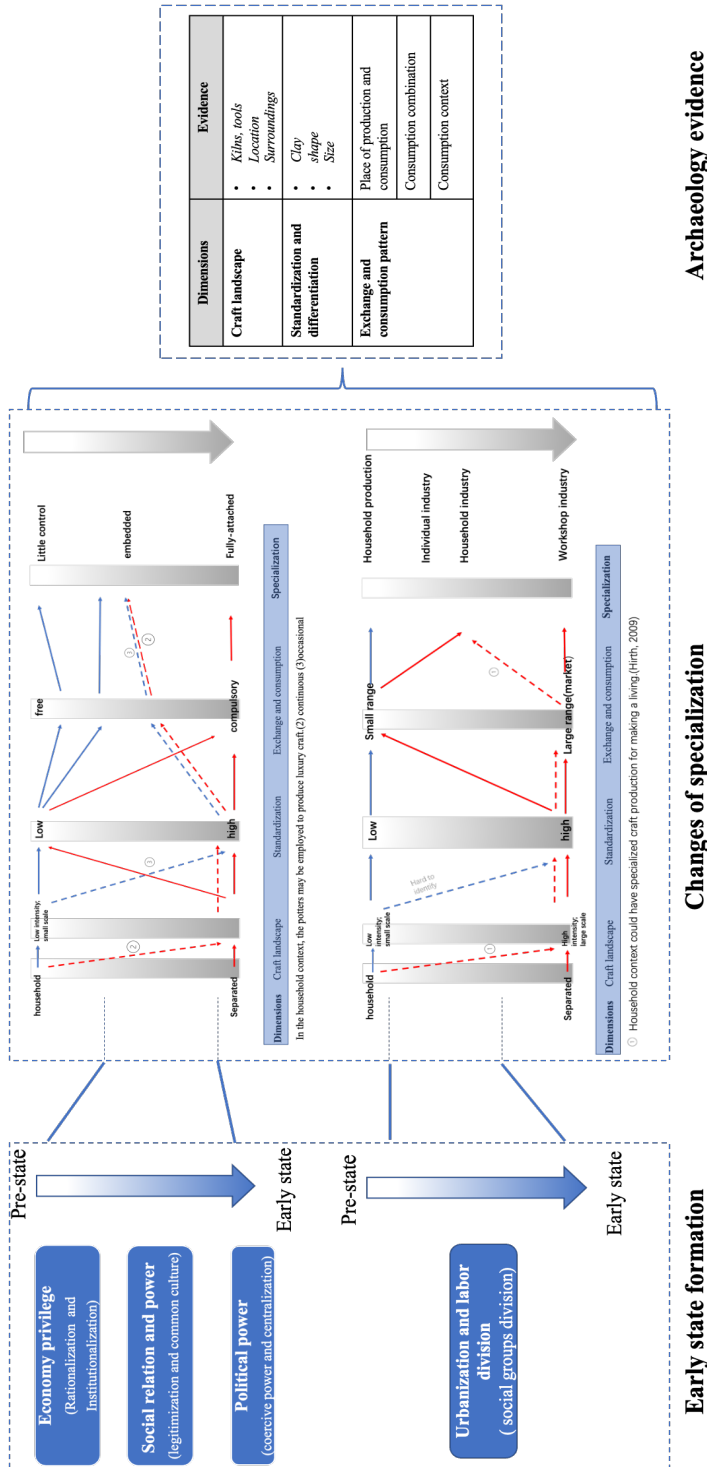


Figure 9 The theoretical model about the relationship between early state and pottery specialization

2.5 Archaeological cultures known as Taosi and Erlitou

2.5.1 Taosi culture

The Taosi culture is considered to have been a highly complex society at the end of the Longshan period. The Taosi site is the center of the Taosi culture. Taosi site is located in the Linfen basin of southern Shanxi Province, Northern China, to the east of the Fen River, the west of Ta'er Mountain, and 7 kilometers from Linfen(Figure 10).Through plant sporopollen research, archaeologists assumed that the vegetation found at the Taosi site should be a warm-tempered deciduous broad-leaved forest, which indicates that the climate during the Taosi period was warm and humid (Zhongguo et al., 2015c). Such a climate provided the Taoist ancestors with a suitable environment in which to live. In this research, in addition to the common livestock bones, they also found deer and alligator bones. This evidence indicates that the Taosi area should have a relatively wide range of water as well as a humid, warm climate. The floatation research shows a similar result: the Taosi site could have not only dryland areas suitable for planting millet but also warm areas that are suitable for rice cultivation (Zhao and He, 2006).

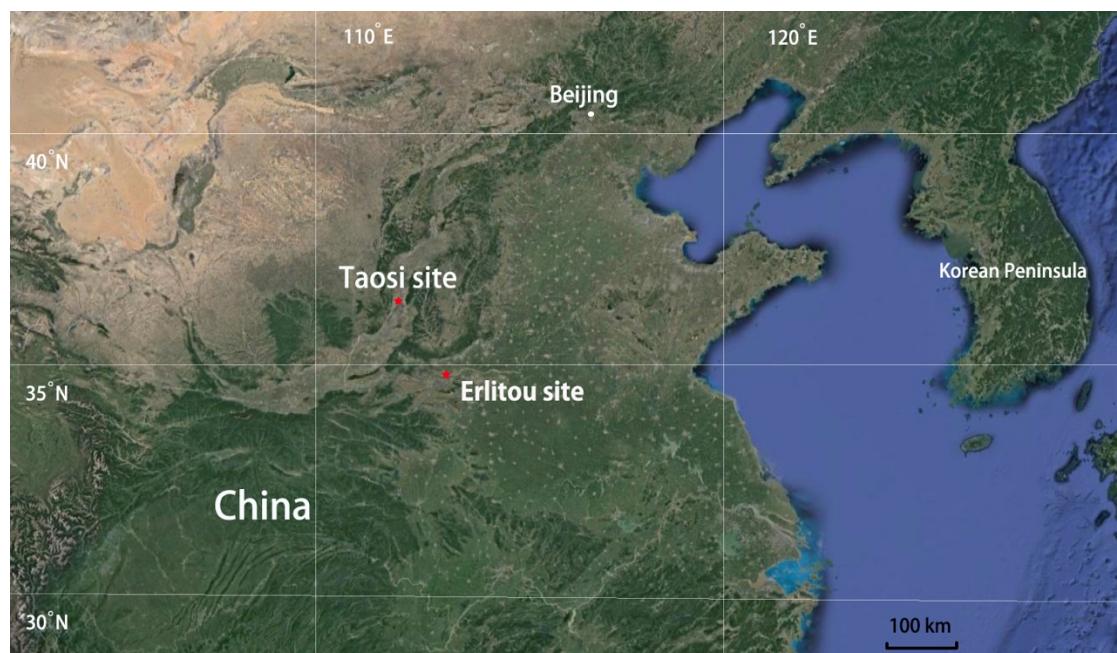


Figure 10 The location of Taosi site and Erlitou site

The Taoist society exhibits a highly complex degree of organization in such a

suitable environment for agriculture and social development. The Taosi site is the largest central settlement in the Linfen basin, covering more than 300 million square meters, and has a clear division of the internal settlement functions into so-called palace areas, general residential areas, burial areas, large storage areas, ritual areas, and craft production areas (specific data not published). The burial areas with more than 2,000 burials show an extreme social differentiation, suggesting a pyramidal social structure in Taosi society.

There is some debate about Taosi society's social development stage, with many Chinese scholars believing Taosi society entered the early state era and was the capital of Yao in accordance with ancient Chinese historical legends. The main basis for this argument is the mention of a well-planned urban form, the presence of a palace and temple area, and a storage area (Zhongguo et al. 2015c). According to the researchers, such urban forms are driven by political power, demonstrating how high-level social stratification and institutionalized political power can have an impact on society as a whole. Some researchers, on the contrary, believe that the Taosi society still belonged to a complex chiefdom society, arguing that although there was a clear social stratification, the central political influence of Taosi society was still limited and did not form a centralized and institutionalized governing body (Miyamoto, 2020). Furthermore, although the burials showed great differentiation, the top elite burials are not separated from the large clan cemeteries. Taosi society's influence is limited, and there is no obvious evidence that the cultural attributes or political system appeared over a large, wide area as well; all kinds of social characteristics still show a certain lack of complexity when compared to Erlitou society. Miyamoto gave a more specific and detailed discussion on the Taosi social system and its various stages of developments. He points out Taosi society has shown some of the characteristics of early states. The Taosi society had a more distinctly different hierarchy structure from the early societies, and the presence of storage areas near the "palace area" in the society implies that the surplus of the society was controlled by the elite, which could provide an economic basis for the elite. On the other hand, he argues that there is no evidence of common ritual activities under central authority at Taosi, and although some valuable

artifacts are found in high-ranked burials, these luxury artifacts mainly adopted religious and spiritual systems from other regions (like Dawengkou culture in Shandong), and the Taosi elite did not establish a unified religious and spiritual system characterized by the Taosi culture itself. Therefore, some of the characteristics of Taosi society have met the conditions of an early state, but some of them still do not meet the criteria of a state we mentioned before. This situation also confirms the diversity of social change and the specific nature of early state formation in China. Combined with the above characteristics of the Taosi society, The complex chiefdoms and states of the previous evolutionary models are not sufficient to describe the society system of Taosi. It can be regarded as the prelude and dawn of the early Chinese state.

Among the previous studies of the Taosi culture, the relationship between craft specialization and society has not been studied much. Especially in the study of pottery, the main focus has been on the use of pottery to stage the Taosi culture and identify the cultural affiliation of the Taosi culture (Gao et al., 1984; Li, 1985; Luo and Tian, 1991; Kubota, 2015). In addition, the pottery production techniques have been restored, including raw material selection (Wang and Wang, 2013), forming, decoration, and firing techniques (Li, 2017). The raw material of pottery clay in Taosi is local. The technology in this period showed a high level of sophistication with the combination of coiling, molding, and wheeling techniques, the advanced structure of kilns, and color-painted decoration (Figure 11). Most of the pottery was made by coiling, and molded and wheeled pottery, mainly in Li and bowls shape, is found concentrated in the Middle and Late period. Such technological advances may also suggest a change in production system. However, the specific organizational patterns of pottery production have not been discussed, and how the pottery specialization relates to the dynamic social system is not clear either. The main reason is that pottery production systems have not been systematically examined. Secondly, researchers have misunderstood social inequalities when studying craft production, where mass production and high levels of specialization are equated (He, 2018). This has led previous studies to simply assume that a high level of pottery specialization existed in Taosi society. But combined with the dialectical analysis of specialization above, we learn that craft specialization needs

to be carefully examined in relation to particular social contexts and related production and social factors. A systematic reanalysis of the pottery production system at Taosi is therefore needed.

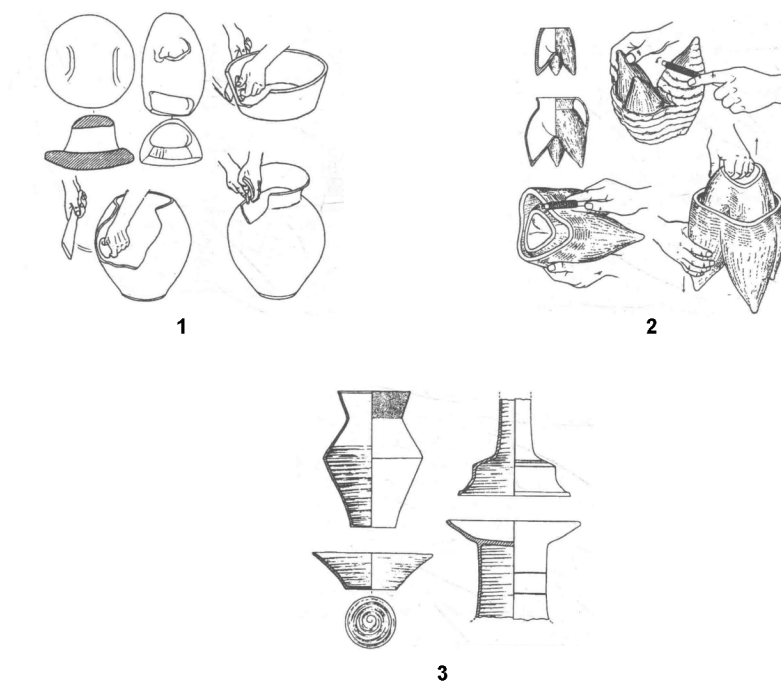


Figure 11 The forming technology in Taosi site:1.Hand-made(coiling or padding); 2. Molding; 3. Wheeling (Li, 2017)

2.5.2 Erlitou Culture

Erlitou society is considered in Chinese archaeological research to be the first wide-territory Chinese state, centered on the Erlitou site. The Erlitou site is located in the Yiluo Basin in Henan Province's western region(Zhongguo et al. 1999)(Figure 10). It is specifically located in the eastern part of a narrow terrace extending east-west between the Yi and Luo rivers, which is alluvial plain terrain. The study of sporulation in ancient plant remains responds to the fact that climate changed at different points in time. In the early period of Erlitou, woody plants are dominated by pine, with a high content of aquatic herbaceous plants, indicating slightly lower temperatures and higher humidity at this time (Zhongguo, 2014). The large decrease of aquatic plants and the obvious increase of dry plants from the second to the third period indicate the deepening of the dryness of the climate. Phase four has more moderate aridity and warmer, more

humid temperatures. Besides the plants, Erlitou is rich in flora, which contains a large number of wild animals (Zhongguo, 2014).

The Erlitou site, as the only mega-settlement in the Luoyang basin cluster, changed the original polycentric settlement pattern of the Longshan era. The rise of the Erlitou site was accompanied by the rapid decay of large settlements over a wide area. The Erlitou site became the economic and political center above the other sites, and the social complexity showed the highest level in the wide area of Shandong, the Central Plains, and the North at this time (Jaang, 2022). Pottery with Erlitou culture attributes was widely distributed beyond the Yiluo basin, with finds from Hubei to Inner Mongolia (Liu, 2005). In Phase 3, in many places such as Shanxi, the proportion of indigenous pottery systems was already smaller than that of Erlitou, indicating the strong cultural influence of the Erlitou society. In addition, prestige crafts appeared in local large burials and in important local settlement centers, suggesting the control of Erlitou's political power over a wide area (Qin, 2019).

There is a consensus on the attributes of Erlitou societies in the present research, and more discussions are focused on the causes of the formation of Erlitou societies and the particular process of early state integration. Recent studies show that the formation of early Erlitou society was a process of social reorganization. Jiaang (2022) indicates that in the late Longshan period, the large central settlements and complex societies in different areas tended to collapse, and then gradually, in the Yiluo region, Erlitou centers were re-established on the basis of the continuous gathering of population, and they continued to develop to form an early Erlitou state that was different from the previous multi-centered settlement hierarchy organization. The concentration of population is regarded as an important factor in the formation of Erlitou, and the entire Erlitou period witnessed large-scale migration as well as the continuous centralization and external expansion of power (Qin, 2019), forming a distinct process of social integration from the early to the third period (the peak of social power) (Liu and Chen, 2012).

The relationship between craft specialization and the formation of the Erlitou State has been widely discussed. The most striking topic is the ritual system of bronze, jade,

turquoise, and white drinking vessels that sustained the political and spiritual relations of Erlitou over a wide area. Bronze, turquoise, and pottery drinking vessels together formed the ritual system of Erlitou, with bronze items circulating in the upper central elite range and turquoise and pottery drinking vessel circulating in both the central and local elite circles (Qin, 2022).

This ritual system was inextricably linked to craft specialization. Bronze and turquoise are considered attached production systems under the direct and strict control of the elite (Miyamoto, 2007). However, the relationship between pottery production and state formation has not been widely studied. Although white pottery was traditionally considered to have received central elite control, recent trace analysis of white pottery clay suggests that Nanwa, the main production site for white pottery, was located at a distance from Erlitou and that there may have been some regional exchange in the sub-centers of the Yiluo Basin (He, 2022). In this case, the original view of subsidiary production is challenged. Therefore, the production of white pottery needs to be further examined with more evidence. Furthermore, for ordinary pottery, as with Taosi pottery, pottery typology has been used to build periodization and cultural clan frameworks in the last century (Peng, 2011; Zhongguo, 1999; 2014). Researchers have argued that the pottery systems of Erlitou society encompassed different cultural characteristics, reflecting cultural diffusion during the integration of the early states. At the micro level, an attempt has been made to restore the majority of pottery production techniques, including raw material selection, shaping, and decorating processes, in terms of the *chaîne opératoire*. There is no progress on production technology, or even a decline (Li, 2017). Only hand-made pottery was found at the Erlitou site, and the pottery body has thickened and differed significantly. Only a small amount of prestige pottery can still be seen at a higher level of production. In addition, Kuji (2010) made a careful observation of pottery samples from Erlitou site and distinguished the existence of different pottery-making traditions in Erlitou society, with the production of lace-mouthed Jars and Li, suggesting the existence of a different pottery-making organization. Furthermore, in the pottery consumption system, an agreement has been reached on the consumption of prestige pottery, especially white pottery and drinking

vessels, which indicate the impact of political economy on pottery production. As for the studies on the organization of pottery production, it is generally believed that some of the prestige pottery came from the attached organizations, while the bulk pottery for daily use basically maintained the pattern of the Longshan period, which remained a household production. This simplified dichotomy ignores the existence of production organizations with varying degrees of specialization within the household unit and raises questions about the nature of white pottery production. Therefore, it is necessary to revisit the discussion of pottery specialization in different kinds of pottery and how the pottery production of society relates to the process of state formation, which has rarely been discussed.

2.5.3 The advantages of case studies

The study chose these two cultures as case studies mainly in terms of continuity of social stages and consistency of cultural traditions. Firstly, the two cultures are in successive stages of social development. Taosi is a precursor to the early state, while Erlitou is the first early state. They share some characteristics in social structure, but certain differences in the degree of complexity have shown up in the two cultures, which imply the process of state formation. The two cultures' sufficient archaeological data also allow for a more detailed examination of the specific changes in the different social systems during the state formation process. Furthermore, the two cultures belong to the Central Plains culture system. There are more similarities in social organization traditions and ideological traditions, so some other bothersome factors, such as ritual factors, can be excluded for comparison. In terms of pottery production, pottery technology did not change dramatically during this period and had a certain stability. This precludes the increase in production efficiency caused by the production technology, which may contribute to the increase in the level of specialization. In addition, the natural environment of the two cultures, especially the central site, did not change dramatically during this period, and the surrounding area had stable clay resources for pottery production, which also precludes the impact of unevenly

distributed clay resources on the level of specialization. In such a case, then, most of the reasons for the change in the production system and specialization came from changes in social factors. The examination of the two cases can effectively explain the relationship between social changes and production specialization.

Besides that, the previous studies on pottery specialization are also revisited. Pottery in both cultures has a certain social symbolism in addition to its practical value. The color-painted pottery from the Taosi site and the Erlitou pottery drinking vessels, especially the white pottery vessels, can reveal the complex relationship between pottery and the corresponding production systems in the process of social change. However, previous studies on pottery production missed an opportunity to systematically examine the relationship between social complexity and pottery specialization, which needs to be further explored.

As a result, the case selection in this study has the advantage of answering the research questions. The Taosi and Erlitou cultures are two important archaeological cultures in the formation of the early Chinese state, and it is possible that their changing social forms can illustrate the particular trajectory of early Chinese state formation. On this basis, a comparative study of pottery production systems and levels of specialization can answer the specific relationship that exists between pottery production and the early state.

2.6 Hypothesis

The research established a model for the archaeological investigation of pottery specialization and early state relations through the above review and summary of relevant theories and studies. In order to answer the research questions of the dissertation, it is then necessary to illustrate and check the models through the study of the two cases. Combining the particular archaeological context of the case studies with the general model, I therefore propose a hypothesis for this study: *from the Taosi society to the Erlitou society, the pottery production became more specialized*. Such general hypotheses can be divided into the changes in three dimensions: craft landscape,

standardization and differentiation of pottery, and exchange and consumption patterns. Based on a review of pottery studies in both cultures, it is clear that pottery could be divided into categories with different practical and social functions: precious or prestige pottery and common pottery for everyday use. They differed in terms of product characteristics, production mechanisms, and may be different in the changes in production specialization. Therefore, under each hypothetical dimension, the study divided pottery into two major categories: P: prestige pottery, and O: ordinary pottery, for the purposes of hypothesis building and testing.

Dimension 1: The study hypothesizes that during the early state formation process, pottery production units became larger in scale and separated from the household context to form specialized workshops, with those producing valuable pottery working more intensively and having closer ties to the power institutions, and ordinary pottery production becoming larger in scale. The separation from the household context shows that pottery production was separated from the original mixed household economy and became an independent economic activity, reflecting the deepening of the social division of labor and the emergence of new social groups and social relations in the early state. With the centralization and institutionalization of elite power in the early state, the control of the precious pottery would also be gradually institutionalized to serve social integration and elite power, so the formation of production units attached to the elite was very necessary.

Dimension 2: From the Taosi to the Erlitou society, the degree of standardization of pottery was to increase significantly. In particular, the prestige pottery, while internally standardized, shows a differentiation tendency from the ordinary pottery, and this differentiation is gradually increased in the process of state formation to not only express the special status of the elite and possession of wealth but also make social stratification institutionalized and standardized, representing the creation and solidification of state government power. The increased level of standardization of ordinary pottery was also the result of the increased scale and efficiency of production, driven by economic interest in the context of urbanization and the deepening division of labor in society.

Dimension 3: The exchange and consumption patterns became more complex from Taosi to Erlitou society. As the economic privileges of the early state elite increased, their access to precious pottery had to be more compulsory, resulting in more unequal forms of exchange and potentially forming a system of tribute and taxation. Ordinary pottery may also have formed a market mechanism due to the expansion of trade. In terms of consumption, from the Taosi society to the Erlitou society, prestige pottery, as an important part of the ritual system, formed a stable, institutionalized consumption pattern over a wide area to maintain the relationship between the central and local levels and was more closely integrated with social stratification.

Table 7 The detailed hypothesis of this dissertation

Hypothesis	Hypothesis dimensions	Detailed hypothesis	Implication for social changes and state formation
<p>Positive link between changes in pottery specialization production and early state formation from the Pottery Taosi Society to the Erlitou Society</p>	<p><u>HDI:</u> The scale of the pottery production unit became larger, and was separated from the household context to form a professional workshop.</p>	<p><u>Prestige:</u> Formation of separate workshops for centralized production and close relationship with the power structure</p> <p><u>Ordinary:</u> Separation from households to form independent workshops and increase in size</p>	<p><u>Yes/No</u> Increased or institutionalized control and economic privileges of the nobility /no change</p> <p><u>Yes/No</u> The division of labor increases during urbanization and new social groups emerge /The division of labor remains at the same level and the household remains as the basic economic unit</p>
	<p><u>HD2:</u> Pottery in Erlitou had more standardized and differentiate trend compared to Taosi</p>	<p><u>Prestige:</u> The level of standardization has increased significantly and is clearly distinguishable from ordinary pottery</p> <p><u>Ordinary:</u> Increased level of standardization</p>	<p><u>Yes/No</u> Increased control of pottery production by the nobility, increased and institutionalized social stratification, increased/unchanged political and economic privileges</p> <p><u>Yes/No</u> Increased/unchanged production efficiency and specialization</p>
<p>The range of exchanges was expanded and exchange relationships became complex beyond reciprocity</p>	<p><u>HD3:</u> The range of exchanges was expanded and exchange relationships became complex beyond reciprocity</p>	<p><u>Prestige:</u> Unequal exchange relationships was deepened ,specific pottery consumption scenarios, fixed wide-area redistribution systems</p>	<p><u>Yes/No</u> Increased elite political centrality, increased social differentiation; increased ability to integrate on a broad scale, increased common cultural consciousness identity / central-local relations remain loose</p>
	<p>Exchange range becomes larger</p>	<p><u>Ordinary:</u> Exchange range becomes larger</p>	<p><u>Yes/No</u> Increased cross-regional trading, increased specialization / intra-regional self-sufficiency</p>

2.7 Summary

This chapter is devoted to a summary and critical discussion of the two parts of the theory and previous research. To begin with, we know from reviewing the unilinear and multilinear theories of social evolution that social change, particularly state formation, is diverse and that separate models cannot explain the trajectory of diverse changes in the world, whereas the concept of social complexity allows examining different changes in society from the divergence of different social directions. The early state was a product of highly developed social complexity. Generally, having professional institutionalized rule, strong centralized political power to avoid division, high social stratification, deepened division of social labor, and a common ideology are all important signs of the state. It reflects a high degree of heterogeneity on both the horizontal and vertical axes. And while some features of the social structure of early states may not be mature or obvious compared to mature states, the ability to integrate behind social change is the most obvious feature that distinguishes early states from former states. Moreover, on this basis, the study summarizes the existence of special trajectories and social changes in the Chinese state formation, which differs from other archaeological cultures. It is noticeable that craft specialization, especially in luxury goods, played an important role in the formation of the early Chinese state. On the other hand, the previous research on specialization in this section explains that there was also a great diversity of motives and performances in production specialization in the process of social complexity, especially the link to the early state formation in China.

The research found that craft specialization was not only influenced by socio-economic factors, but that the political and economic strategies of early state leaders, how they played a leading role in social integration, and the interaction between non-elite and elite groups all led to different degrees and patterns of specialization. Thus, an examination of the relationship between the early state and specialization needs to take into account both the general relationship and the particular socio-cultural context. The previous studies on the relationship between pottery specialization and the early Chinese state may have lacked such considerations. I therefore pose the research

questions of this dissertation study.

In order to answer the research questions, I develop a holistic theoretical model in three steps to explain the complex relationship between pottery specialization and the early Chinese state. The model includes discussing how to determine the degree of specialization, the archaeological evidence needed and its changing dynamics, and finally, how the changing archaeological evidence can reflect the relationship between pottery specialization and the early state. This framework does not attempt to rigidify the relationship. Instead, the model believes that the change in pottery production and specialization is a dynamic process, and each dimension may not change in concert but most likely changes individually. Therefore, the model is not trying to fix the form and process of changes in specialization along with the formation of the early state, but to explain the possibilities of each dimension of changes in specialization and the connection with social complexity, and to observe the special connection with the early Chinese state.

Chapter 3 Material and Methods

This chapter focuses on the data and methods used in the study. The chapter first explains the material of the study, including the criteria for selecting the samples and the spatio-temporal properties of the samples. The different quantitative methods chosen for the different samples are also discussed in this part. It also explains the advantages of choosing different quantitative methods compared with the traditional qualitative methods.

3.1 Materials

In this research, multiple types of evidence on pottery production from the Taosi and Erlitou cultures were selected as material. Because it is important to consider each variable contained in the entire production system in an integrated manner, as mentioned above, the study chose a variety of research materials for a comprehensive examination.

The materials needed for this study have been described in 2.4.2.1 Archaeological evidence selection model. To begin with, direct evidence contains production equipment, tools, and related debris (Costin, 1991). In Chinese ceramic production tradition, kilns are widely used, so the kilns were selected as the important clue for identifying the production loci. Furthermore, pottery-making tools may have been diverse and multi-material, and usually perishable materials such as wood are not easily preserved in an archaeological context. Also, some tools, such as knives, may have been used for the production of other crafts at the same time, which may cause confusion in the research of pottery production activities. Therefore, this study chose pottery pads as a representative of pottery-making tools for analysis (Li, 2017). Pottery pads are frequently found as necessary forming tools and were only used for pottery making activities, so they are ideal as an object to investigate production activities.

In addition, as for the indirect evidence from pottery, the following selection criteria were specified based on the basic requirements of statistical analysis and

considering the possible influence of different utilitarian functions on the results: 1. pottery samples containing more than 30 complete vessels; 2. at least one type of each function was chosen. Criterion 1 ensures the scientific nature of the statistical analysis. The special nature of archaeological data often reveals a small sample size. Too small a dataset may produce errors in the results of the statistics. Rice (1987) empirically suggested that a minimum number for a set of data in an archaeological statistical study is 30, and this study adheres to such a criterion to ensure the statistical validity. Criterion 2, on the other hand, ensures the comprehensiveness of the production system examined and the validity of the cross-sectional comparison. The functional properties of pottery also affect its production behavior. Underhill's long-term study (2002) on Chinese prehistoric pottery suggests that the cuisine-related pottery, especially that related to the feasting activities, tended to be specially treated. Therefore, this study covers pottery with different functions and compares pottery with the same function in two cultures to reduce the likelihood of misleading final results. Moreover, different functions of pottery can have different social meanings in the same society. For example, serving and drinking pottery in different cultures may have ritual significance and be produced in different production systems, so the examination of pottery with different functions also helps to fully examine the production systems of pottery with different social meanings in the whole society and the special relationship between them and the specific social context.

Based on the criteria above, the selected sample sizes are listed in Table 8, where the complete ware is the sample size used for shape analysis and the overall number is the sample size used for size analysis as well as consumption pattern analysis. Due to the limited published data, the complete pottery from the Taosi site is mainly from the early period, with only sporadic samples from the middle and late periods, so the production system discussed in this study is mainly for the situation in the early period of the Taosi culture. In addition, among the pottery samples, the Erlitou culture's drinking vessels are unique in that they have culturally specific meanings and the potential for redistribution over a wide area (Tokudome and Liu, 2015), which is important for studying the production system and specialization of prestige vessels and

the relationship between production and the emergence of the early state. So this study extends the Erlitou drinking vessel samples to the entire Erlitou culture site to examine separately the production of pottery as a ritual vessel, the standardization trend, and the relationship between the degree of standardization and social change (Table 8).

Table 8 The samples of this study

	Taosi	Number (complete/total)	Erlitou	Number (complete/total)
Cooking	Jia (斝)	35/73	Jars with deep abdomen (深腹罐)	60/477
	Li (鬲)	31/77	Li (鬲)	37/137
Storage	Jars with large orifice (大口罐)	54/75	Jars with large orifice (大口尊)	63/92
Serving	Dou (豆)	39/79	Dou (豆)	86/129
Drinking	X		Jue (爵)	51/95
	X		He (盃)	58/101

Because of the limited access to pottery sherds and the small number of published samples, the study chose to reanalyze previous scientific clay analysis results in the raw material analysis for pottery.

In addition to the examination of the production system, changes in the social system are also an integral part of this study. In addition to summarizing previous research, this paper reclassifies and analyzes mortuary practice from both cultures in order to examine the social system (changes in organizational, political, economic, and ideological systems) from Taosi to Erlitou culture in depth. It can also provide a more specific social organization and ritual background for the examination of prestige pottery.

Table 9 The drinking vessel samples in the wide area

Jue			He		
Site	Area	Count	Site	Area	Count
Erlitou	C	30/56	Erlitou	C	47/80
Nanzhai	Y	6/11	Nanzhai	Y	6/9
Dongmagou	Y	1/1	Dongmagou	Y	1/1
Nanwa	Y	1/3	Nanwa	Y	0/1
Yucun	Y	1/1	Tuoli	Y	1/1
Zaojiashu	Y	0/1	Baiyuan	Z	0/1
Shaochai	Y	0/1	Xishicun	Z	1/1
Baiyuan	Y	0/1	Baliqiao	Z	0/1
Dashigu	Z	0/1	Niangniangzhai	Z	0/1
Luodamiao	Z	1/2	Dashugu	Z	0/2
Xishicun	Z	0/1	Yangzhuang	S	2/3
Baliqiao	Z	1/1			
Niangniangzhai	Z	0/1			
Yangzhuang	S	5/5			
Rangdong	S	1/1			
Zhengyao	J	1/5			
Dongxiafeng	J	1/1			
Xiyacun	J	1/1			
Dachai	J	1/1			
19		51/95	10		58/101

*area C: central Erlitou; Y:Yiluo region; S:Southern region;J:Jinnan region.

*count: complete ones/ total samples

For the dating of the materials, there are now official reports for both sites, and there is now consensus on the conclusions of the cultural staging, so the study chose the staging results in the Taosi report (2016 published version) and the Erlitou report (1999 and 2014 published version) as the dating benchmark, and matched the pottery from the other briefs reports with the staging samples in the official report to complete the dating of the materials for the whole study.

3.2 Method

3.2.1 Overview of methods

The examination of production systems, especially production specialization, is not simply an analysis of a certain procedure in production activities or a certain

attribute of pottery, but is to include as much information and examination as possible to synthesize the situation of each component of the production system and to synthesize the entangled relationship between them and the whole production system. Based on the above considerations, the study divides archaeological data into two categories: direct evidence and indirect evidence and uses diverse methods and strategies to analyze the characteristics of different kinds of evidence. For direct evidence, this study uses spatial analysis to identify the location of production units, the distribution characteristics of production units, and the relationship with the surrounding landscape. For the indirect evidence, quantitative studies were chosen in order to analyze more objectively the characteristics of the pottery and the production system behind it and to make a more intuitive comparison between two different cultures. Qualitative studies on pottery data can only be observed, not measured, which inevitably leads to subjective results. Quantitative studies, however, can overcome this shortcoming by presenting a more objective and direct picture of pottery properties and production systems. Particularly when comparing different cultures, qualitative research often leads to more direct and clear comparisons. Furthermore, a multi-strategy study of materials with different attributes can provide a more comprehensive understanding of pottery production, pottery specialization, and the entanglement of pottery production with the emergence of early states.

3.2.2 Direct evidence examination: spatial analysis

Spatial analysis in archaeology refers to the important information that can be obtained from the spatial relationships between objects and the need for an objective method to characterize these relationships in order to understand the objects themselves and their relationship to society (Hodder and Orton, 1976). It is a map-based approach. As mentioned in the previous chapter, the spatial relationships of the direct evidence are effective in revealing the form of production organization, especially in providing information about the intensity, context, and scale of production (see the table for details). Therefore, a spatial analysis of direct evidence is essential.

Unlike the general spatial analysis used in the quantitative study of settlements on a large scale, the spatial analysis for specific craft production tends to focus on the relationship with the remains related to production activities in a specific small space and to examine production activities in combination with chaîne opératoire (Lemonnier, 1986; Erb-Satullo, 2022). In addition to the statistical analysis of direct evidence of location and spatio-temporal variation, this study will also examine the patterns of arrangement within production units, the relationship between tools and equipment, and the relationship between production units and the surrounding landscape to investigate the organization, intensity, scale, and context of the production dimension. Such analysis can provide evidence for the identification of production systems and the degree of production specialization.

3.2.3 Indirect evidence examination: quantitative analysis

The properties of pottery include its raw materials, traces left during the production process, shape, size, decoration, and so on. Most of them are not quantitative variables. Therefore, some non-numerical variables of pottery production attributes are first quantified. Two main quantitative methods are applied in this study: Geometric morphological analysis (GMM) to quantify the shape of pottery; and CV to quantify the degree of dimensional standardization of pottery.

Methods of Quantifying Pottery Attributes

A. Geometric morphological analysis (GMM): quantifying shape attributes

Geometric morphometric analysis is a relatively new field of research in the study of ceramic shape compared with typological studies in archaeology. It often entails computationally demanding measurements capable of analyzing numerous dimensions of an object simultaneously (Rohlf and Marcus, 1993; Lele and Richtsmeier, 2001). In previous studies, the method to study morphological features has mainly been traditional typology, but its subjectivity and unrepeatability have been questioned

(Wilczek et al., 2014). Compared with traditional typology, a geometric morphometric analysis enables researchers to examine ceramic morphological variation in fine detail and comprehensively. It is based on testable quantifications of the shape data. This research uses one way to do geometric morphometric analysis: elliptical Fourier analysis (EFA).

EFA is a method based on the Fourier transform, where the closed contour is decomposed into a series of mathematical functions (harmonics): a collection of sines and cosines and their corresponding harmonic coefficients. Each harmonic is a function describing an elliptic shape, defined by four coefficients: two for the x coordinate and two for the y coordinate. The lower order harmonics describe the general shape, while the higher order harmonics relate to the fine details of the contour. Although an infinite number of harmonics can be used to describe the contour, a reasonable approximation (e.g., 99%) of the original shape can be made using a limited set of coefficients. By retaining a certain number of harmonics and the corresponding coefficients, the contours can be compared quantitatively using multivariate statistics.

EFA originated from biological research and is used to evaluate shapes qualitatively (Kuhl and Giardina, 1982), and it has been applied here to analyze the degree of variation in the shape of a closed, two-dimensional archaeological object (Wilczek et al., 2014; Fox, 2015; Hoffard et al., 2019; Wang and Marwick, 2020; Wang et al., 2021). Compared with other GMM analyses such as landmark and distance analyses, the effectiveness of EFA in ceramic morphological attributes and measurement standardization has also been explored and recognized. EFA is able to describe the continuous contour more comprehensively, which overcomes the analytical errors caused by the subjectivity of the selected examined points in the landmark and distance methods. In addition, EFA analysis has advantages compared with traditional typologies. Wilczek et al. (2014) argue that such outline-based methods are reliable for studying ceramic shape after comparing the results of EFA and traditional typologies. Similarly, the research that investigates the morphological variation of pottery at the site of Gansu-Zhanqi (Wang et al., 2021) supports Wilczek's argument and argues for the validity of EFA in archaeological ceramic shape analysis.

In this study, EFA was performed using a computer program called "SHAPE" (Iwata and Ukai, 2002). Figure 12 depicts the specific steps of analysis that were taken. The quantification of the shape is done according to the above steps, and the shape software can provide the results after the principal component analysis.

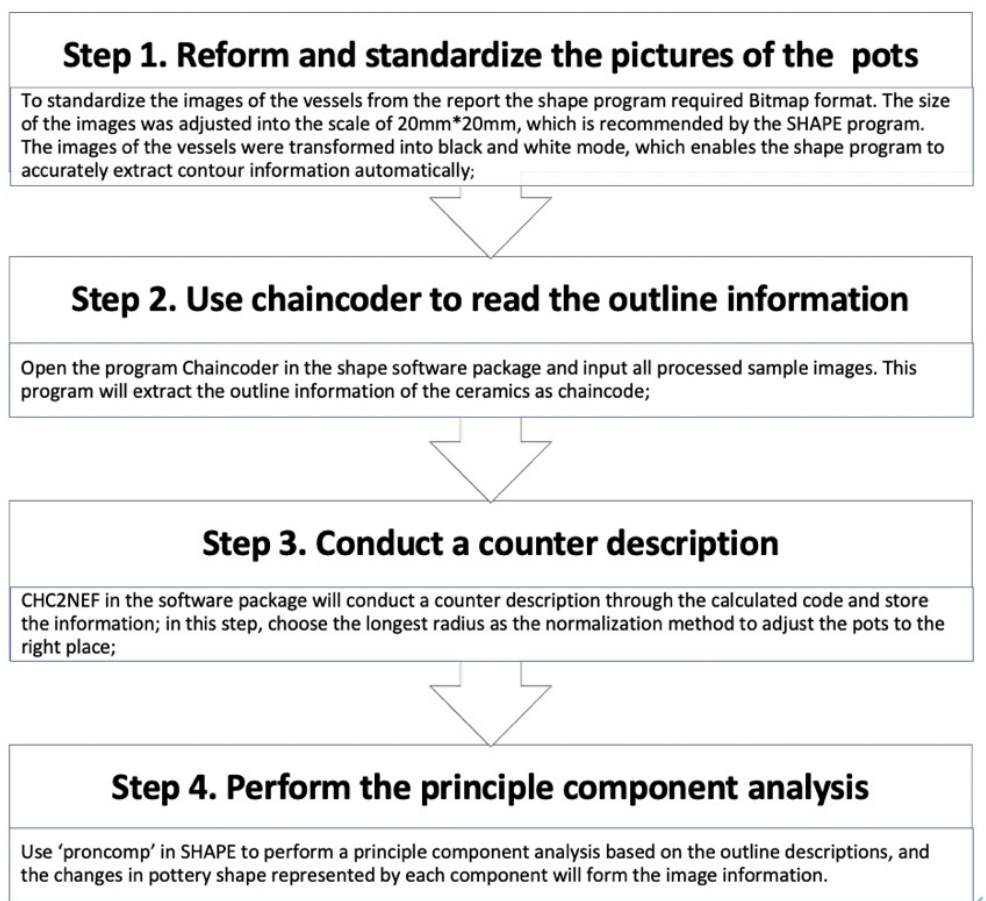


Figure 12 The workflow of using Software SHAPE

B. Coefficient of variation (CV): quantifying standardization degree of size attributes

The coefficient of variation (CV) of the ceramic measurements was calculated to demonstrate the degree of variation in different ceramic groups ($CV = SD$ (standard deviation)/mean*100). It is the most common method of examination in previous studies of pottery standardization. Although the direct link between production specialization and a certain value of CV remains controversial, a low CV value represents a relatively small degree of change, and this is widely applied in ceramic

research (Longacre et al., 1988; Costin and Hagstrum, 1995; Eerkens and Bettinger, 2001; Roux, 2003; Blackman et al., 1993). The CV allows this research to compare size variation in different ceramic groups and discuss the degree of standardization in the ceramic assemblage.

However, the examination of CV is also influenced by cumulative blurring, which causes errors in the standardized results as a result of the accumulation of specimens over time. This is also an inevitable error in archaeological studies compared to ethnographic pottery studies. So in this study, CV can only be examined by selecting samples from a similar period (consistent stratigraphy) and consumption context. In addition, the size of the rim of the pottery was chosen for standardization. Underhill's ethnographic survey in Guizhou found that the rim of the pottery is the most representative of the production expectations and technical habits of the potters. Therefore, the rim may be able to reflect the variation in size of the pottery.

C. Factor analysis and cluster analysis

Factor analysis and cluster analysis are mainly directed at the study of the classification and behavior of burials. The classification of Taosi and Erlitou burials made in previous research has always used the traditional qualitative method, and the results are considered to represent different degrees of hierarchical differentiation in the society. However, this approach solely relied on the labor expenditure principle, whose outcome was highly subjective and difficult to verify. This study applies a multivariate analysis. Factor analysis is used to investigate the correlations within the mortuary data. The statistical factor scores quantify the differences between the combinations of burial objects in different tombs and allow clarification by cluster analysis to investigate their different social meanings.

Factor analysis examines the dependencies within a correlation matrix of original variables and attributes; a number of variables with intricate relationships to each other are widely used to investigate common factors representing underlying dimensions in archaeological attributes and to elucidate socio-cultural mechanisms behind such

dimensions (McHugh, 1999). In the 1960s, factor analysis was applied to archaeological research in correspondence analysis, both of which use a similar dimensionality reduction approach to represent complex relationships among variables in a manageable way (Doran and Hodson, 1975). Especially in burial studies, factor analysis has been considered an important method that could summarize the common meanings of attributes in a burial through the structure of their interrelationships, which may reflect certain social relationships or social meanings, such as gender and age divisions, evidence of chronological change, or evidence of vertical status differences (Baxter, 1994).

Cluster analysis is a common quantitative classification method based on internal similarity and partitioning between groups to categorize data into different groups (Rencher and Schimek, 1997). Based on the results of factor analysis, the research applies hierarchical clustering to classify the different burials.

Based on the different functions and characteristics of the abovementioned methods, this study uses a combination to classify burials. This classification allows for a more objective examination of possible funerary norms and potential relationships between different attributes of mortuary practice.

Multivariate analysis of above results

A. Principal components analysis (PCA)

PCA is a multivariate analysis method of analyzing the variance-covariance structure of the original variables by transforming multiple variables into a small number of composite variables (principal components) through mathematical operations. It is dimensionality reduction thinking, using a new combination of the original variables to form several composite indicators, i.e., principal components, which can retain the main information of the original variables on the premise of dimensionality reduction and problem simplification (Drennan, 2010). Therefore, it is easier to grasp the main contradiction in the study of complex problems.

In archaeological research, PCA has been widely and multifariously applied. For example, VanPool, in his PhD dissertation on projectile point morphology, measured 21 metric traits at 424 points over the entire basal shape and subjected the results to PCA to examine the specific parts of the projectile that produced significant variation and were classified. Similar studies have been conducted for pottery shapes (Karasik and Smilansky, 2011). Another application of PCA is the analysis of the provenance of ancient ceramics. After the analysis of ceramic clay using different scientific methods, studies usually use PCA to investigate the chemical composition for grouping, classification, or comparison. Therefore, PCA can effectively reduce the dimensionality of the known quantitative results of archaeological data and facilitate further analysis of the reduced principal components using other statistical methods to achieve the purpose of archaeological research.

This study uses principal component analysis in two main applications. Firstly, principal component analysis is used to examine the shape attributes that have been quantified, and the shape software mentioned above can directly display the results of principal component analysis. In addition, the original clay composition data published in the previous study was also re-examined using principal component analysis. The results obtained from the above two aspects of the study were used for the subsequent comparisons.

B. ANOVA and MANOVA

ANOVA (Analysis of Variance) is used to compare the variance between the averages of different groups. It is used in many scenarios to determine if there are any differences between different groups. The result of ANOVA is the "F statistic compare the variance between the averages of different groups. It is used in many scenarios to determine if there are any differences between different groups. The result of ANOVA is the "F statistic." This ratio shows the difference between the within-group variance and the between-group variance and ultimately produces a number that, if significant, is less than 0.05 and indicates a significant difference between the two groups, while

less than 0.01 versus less than 0.001 represents a further significant difference between the groups (Drennan, 2010; Shennan, 1997). So, to compare whether there are differences in the material and shape of pottery between groups, i.e., whether they come from different production units or whether there is a conscious effort to produce differences (particularly between nobles and commoners), the ANOVA is an effective analysis method to test.

MANOVA (multivariate analysis of variance), which denotes analysis of variance on multivariate data, is a one-way extension of ANOVA. As a multivariate process, MANOVA is used when there are two or more dependent variables and is usually followed by a significance test involving each dependent variable separately. In this study, after testing ANOVA separately, the differences between groups were examined using MANOVA synthesis for the prestige pottery to investigate more information (Drennan, 2010; Shennan, 1997).

In addition to ANOVA and MANOVA, the article also uses simple statistics to analyze the number of pieces of pottery consumed and distributed in different scenarios, thus analyzing the possible existence of different patterns in pottery consumption and distribution.

3.3 Summary

This section describes the research materials to be used for the study and the quantitative research methods to be used for different properties of the material. Quantitative research methods are effective in overcoming the subjectivity of previous traditional typologies and qualitative studies and allowing for a more visual comparison of data across two cultures. The use of such diverse research methods allows for an integrated and comprehensive examination of the production systems of pottery in both cultures (Figure 13). Similarly, based on the model developed above, this combination of methods can also be used to determine the level of specialization. The judgement of specialization need to combine three types of criteria. These criteria could be implied by different archaeological evidence. Different methods for the three criteria of

specialization and the corresponding archaeological evidence can also be effectively examined (Figure 14). Therefore, such multiple methods and the combination allow both a comprehensive examination of the production system and a judgment of the level and possible forms of production specialization. It is very suitable for this study.

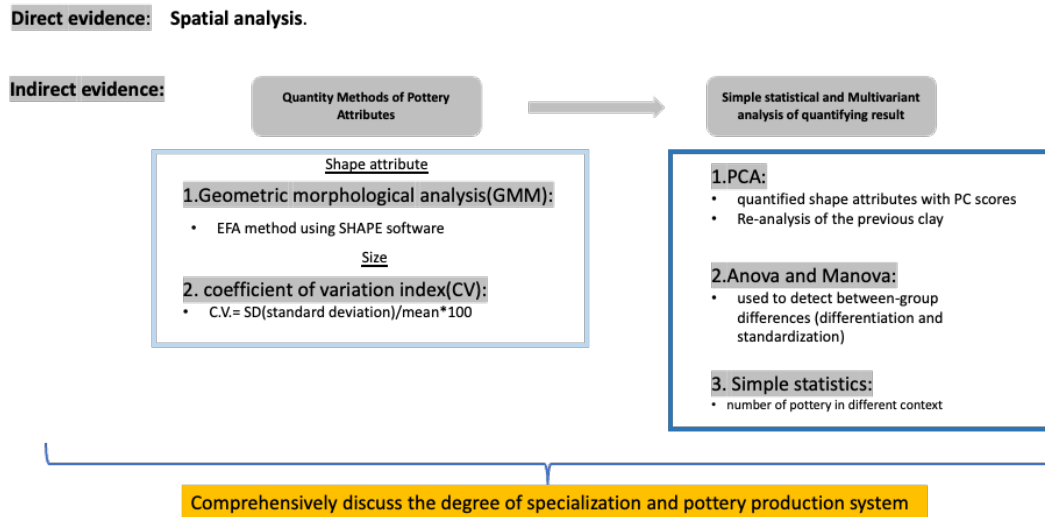


Figure 13 The multi-methods used in the research to study the production system

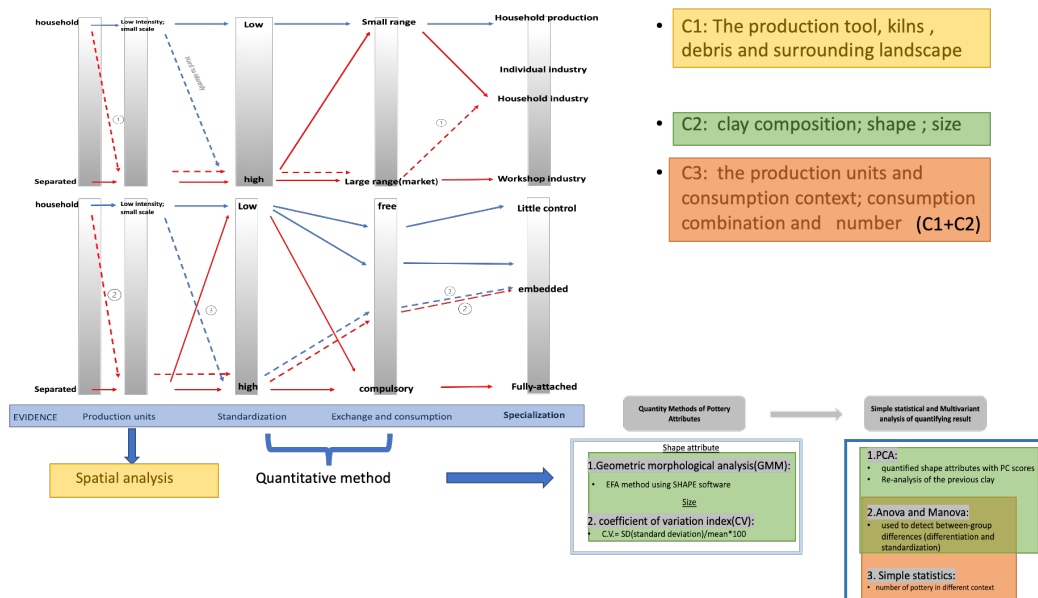


Figure 14 The feasibility of applying the same multiple methods in studying specialization

Chapter 4 Pottery production system and specialization in Taosi

Culture

4.1 Introduction

In this chapter, I focus on the pottery production system at the Taosi site and the possible level of production specialization. The Taosi site, as the central settlement of the Taosi culture, has a huge urban area and a complex social structure and is considered to be an indispensable part of the formation of the early state in China. A large amount of pottery has been found in the early period and has been studied from multiple perspectives by previous scholars. However, the specific organizational patterns of pottery production have not been discussed, and how they relate to the dynamic social system is not clear either. As a result, this chapter intends to provide a thorough examination of the evidence for pottery production, systematically illustrate pottery production at the Taosi site, and then discuss the relationship between social organization and the production system. It should be noted that due to the limitation of the data, the main discussion of period specialization is about the early period of Taosi site, although the middle and late period pottery production is mentioned, but because only a small amount of complete pottery was found in the middle and late period, the evidence is insufficient, so it is not the focus of this study.

The research in this chapter is divided into four parts. The first part is about the social structure of Taosi society. It includes the chronological framework for the discussion in this chapter, discussions on settlement patterns and analysis of mortuary practice at the Taosi site. The settlement patterns include the spatial distribution of different functional areas as well as how such patterns changed over time. Similarly, in the study of mortuary behavior, this part adopts a multivariate analysis method to classify the burials found in Taosi cemetery, exposing the pyramidal burial stratification structure and complex social differentiation in the society. The settlement patterns and mortuary analysis could provide a corresponding context for the pottery excavated in

different areas and facilitate the later comparison of pottery from different contexts. The second part will focus on the study of pottery production evidence. It includes a study of the production equipment and tools, their spatial and temporal distribution within the site, and their relationship with other production activities in the surrounding landscape. In addition, four different types ($n > 30$) of pottery vessels representing different functions are selected for the study of morphological geometry and dimensional variation. Such results are compared in different contexts to discuss whether there is a clear tendency for standardization or diversification of these vessels. Such results can also imply the socio-political motivations and systems that influence such results. Then, Part three building on Part Three, further discusses the consumption and exchange of pottery at Taosi. Part four specifically focuses on the color-painted pottery from the Taosi cemetery. The examination investigates the connection between different types of painted pottery and their shapes and compares the distribution of different types of painted pottery among different types of tombs to discuss the special will of the elite to consume the color-painted pottery and the involvement and influence of such wills on the production of painted pottery. Finally, combining the evidence from the above four aspects, the production system at the Taosi site will be comprehensively studied.

4.2 The social system of Taosi Culture

This part focuses on the analysis and discussion of the social system of Taosi society, combining previous studies as well as quantitative burial analysis. Firstly, the staging of the Taosi culture will be clarified and used to determine the temporal criteria for the changes of Taosi society in different periods. Secondly, the study summarizes the changes in settlement pattern of Taosi Culture, indicating the variation of socio-political power, and economic system of Taosi society during the three periods. Finally, the research applies quantitative methods to re-analysis the Taosi cemetery in an attempt to explain the social organization of Taosi society. These three parts can be combined to illustrate social system of the Taosi culture.

4.2.1 Chronological framework

The chronology studies of the Taosi site are based mainly on pottery typological studies. The central debates mainly focus on the "three-period" argument proposed by He (2006) and Gao (2007) and the "two-period" one supported by Dong (1998) and Kubota (2015). The main difference is the focus on whether the early period argued by the "three-period" argument belongs to Taosi culture, as characterized by some traditional cooking vessels showing similarities with the Miaodigou II. However, He (2006) has proposed the strong idea that, based on quantity studies on Taosi and Miaodigou II's cultural attributes in the early period, the heterogeneous factors have far surpassed similar ones. There are numerous published data that show that the previous period saw a group of pottery assemblages independent of Miaodigou II. Therefore, the early period of the Taosi site could be regarded as the beginning of Taosi culture. Such a chronology framework was also used in the official report of the Taosi site and became the most commonly used chronology for the site(Figure 13).

According to the radioactive ¹⁴C age determination, the period of the Taosi site is about 2300 BC–1900 BC (early period: 2300–2100 BC; middle period: 2100–2000 BC; late period: 2000–1900 BC), providing a basic chronology framework for Taosi studies (He, 2018).

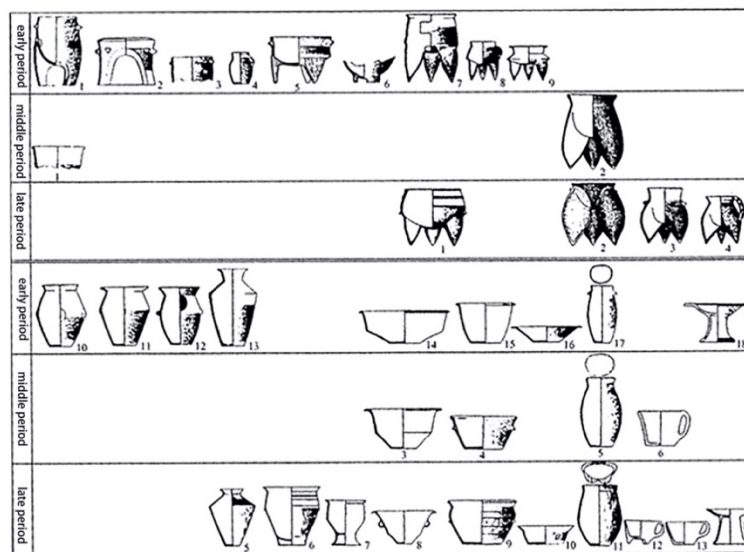


Figure 15 The pottery assemblages in different periods at Taosi (adapted from Gao et al., 1984: Fig.1)

4.2.2 Settlement pattern of Taosi site

The settlement at Taosi has witnessed dynamic socio-political changes within the three periods mentioned in Table 10. In the early period, an urban site appeared in the northeastern area surrounded by a rammed earth enclosure (Zhongguo et al., 2015c). There was a concentrated residential area for commoners in the northern area. The types of artifacts showed a relatively affluent society, including houses, stoves, pits, and pottery kilns (Zhongguo and Linfen 1980, 1986). In the middle area, a residential site was also found and regarded as the elite class's habitation by the excavators (Zhongguo et al., 2015a). There are also small residential areas on the western edge of the urban area and scattered residential remains in the southern district (Zhongguo et al., 2015c). It is worth noting that people also began building a large and concentrated cemetery in the southeastern quadrant outside the city (Zhongguo and Linfen 1983; Zhongguo et al., 2015c) (Fig. 16).

Table 10 The settlement pattern and social changes of Taosi society (based on He, 2013)

Period division	Radioactive C ¹⁴ dating	Settlement arrangement	Features
Early	2300–2100BC	The elite residential area in the central area; the commoners' residential area in the north; a concentrated cemetery in the southeastern part.	Already stratified society
Middle	2100–2000BC	A "palace" complex in the center; Large storage in the southeast; a separate royal cemetery in a new enclosure; a craft workshop area in the southwest; scattered residential areas	Advanced and complex urban arrangement and highly concentrated political power
Late	2000–1900BC	The elite burials have been destroyed; walls leveled, the palace complex destroyed, and the sacrificial area and craft workshop area abandoned	Social collapse

During the middle occupation period, the earth enclosure was expanded, forming a much larger urban center by the palace compound developed from an elite residence in the early period (He, 2009b). The rest of the urban area was made up of spatially separated zones for elite ritual activities, craft production, and lower-class residences. Large storage pits have also been found in the northeastern quadrant (Zhongguo et al., 2008; He, 2018). This storage area is close to the palace area and contains houses for guarding the place. This suggests that the city's food supplies were controlled and regulated by the elite. The scattered residential areas also continue to exist. In the newly built small city located at the southeastern edge of the settlement, there is the royal tomb area and the sacrificial area, which are relatively separated from the early cemetery (Zhongguo et al., 2003; He, 2009a). The southwest quadrant is a craft workshop area. According to the excavators' description, there are sizeable rammed earth buildings in this area that may have been the official office of the elites supervising and managing handicraft workshops (He, 2009b; 2018).

The late occupation phase at Taosi was a period of social collapse. The elite burials were destroyed, sections of the city wall were leveled, the palace and observatory were destroyed, and the sacrificial area and the craft workshop area were abandoned (He, 2015). The numerous skeletons show evidence of violent death (Zhongguo et al. 2015a). The site was no longer carefully organized according to activity zones or social status. Instead, commoners' residential areas were spread across the entire site, including areas formerly only occupied by elites (He, 2018). The ordinary residential regions were mainly concentrated in the southeast and northwest areas (Zhongguo et al., 2015c).

It is obvious that the urban function and arrangement experienced massive changes over the periods. From the early to middle period, the functional zoning became more diversified with separate artifact production areas, isolated cemetery areas, and the palace area. Among these, the royal cemetery was located in a different place to the early one, and the rammed earth walls were deliberately built to distinguish them from other functional areas. All this implies the concentration and strengthening of political power in this period. In the late period, various facilities with political functions were

destroyed. Scholars believed that it was retaliatory destruction (Gao, 2017). As a result, the political position of Taosi was greatly weakened.

The differentiation of the functional areas within such different periods also represents a difference in the context of pottery demand and consumption. It could help understand the functions and dynamic changes of human activities at the Taosi site and provide an essential context for the study of pottery production.

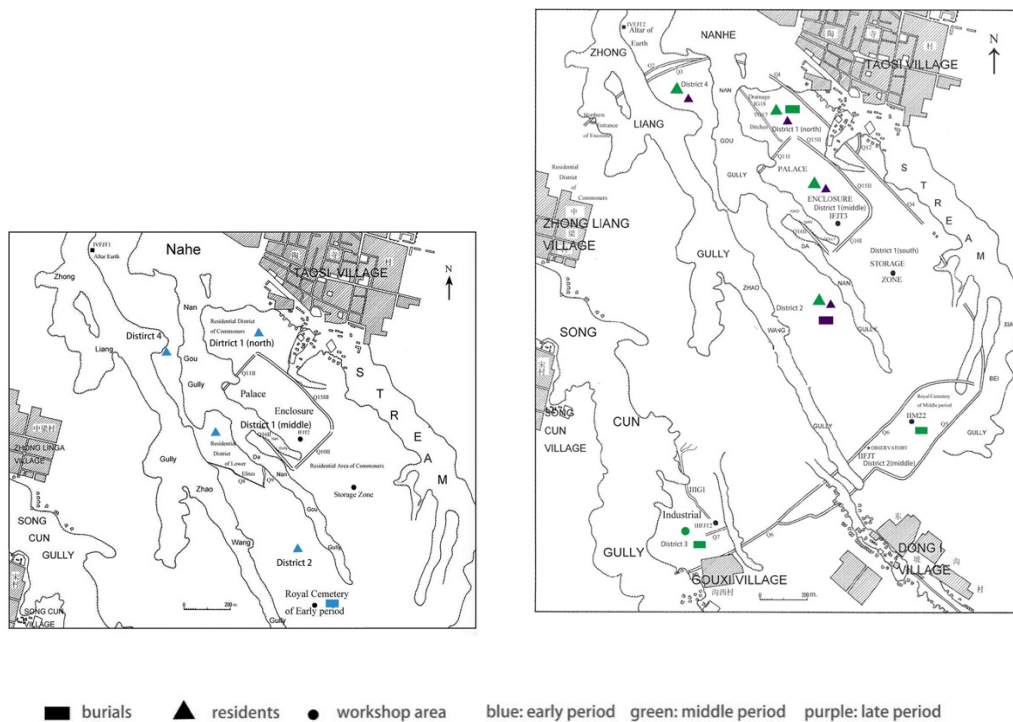


Figure 16 The settlement pattern of Taosi site. (1) early period (2) middle and late period (After He, 2018)

4.2.3 Mortuary practice of Taosi culture

The Taosi cemetery is located in the southeast of Taosi, far from the main population activity area (Figure 17:1). So far, 1426 graves have been discovered (Zhongguo et al., 2015). All are earthen pit vertical burials, highly uniform in shape, with more than 80% of them oriented between 110 and 160 degrees, indicating shared burial customs and the same clan identification (He, 2018). The Taosi cemetery has a well-planned layout (Figure 17:1) and is considered to be a communal cemetery of Taosi society (Gao, 2007). According to stratigraphy and pottery typology, these burials

belong to the early and late periods of the Taosi site, and no Taosi inhabitants were buried in this cemetery in the middle period. However, there is considerable inner variation within these tombs. Most of the burials are small (under 1 m²) and do not have any grave goods, but the largest burial can be 18 m² (Figure 12:2). Only 265 burials possessed funerary objects, and these varied greatly in type and number (Dai, 2019). More than 82% did not have any burial items. However, one burial included up to 200 funeral items. Such considerable differences in the number of burial objects and the area of tombs imply the serious social division of Taosi society.

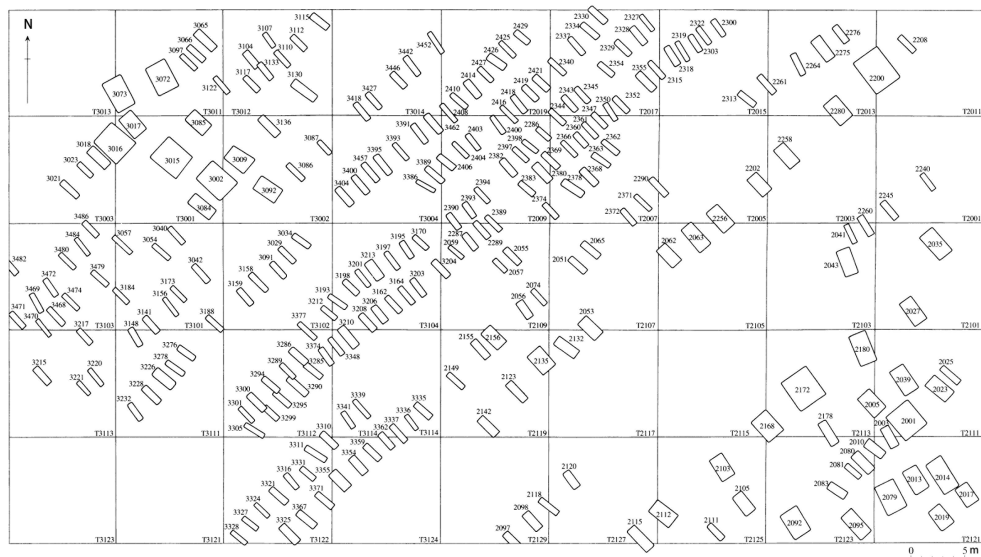


Figure 17 The cemetery and burials in Taosi site (1) the arrangement of cemetery; (2) M2001; (3) IIM22

The original report classified the burials in the Taosi cemetery into five types, wherein the first three types were further divided into different subclasses. Based on such classification, Miyamoto (2005) concluded that the Taosi cemetery was broadly divided into three classes: large, small, and medium, defining different social classes,

from the elite to general commoners. Dai (2019) delineated the possible differences in burial categories based on gender. Previous studies have recognized the Taosi cemetery as a large communal cemetery. The obvious differences in grave scale and the number of grave goods may represent the different hierarchical social units. They also argued that there is a strict hierarchical order between different ranks of graves and that the complete ritual system is reflected in the burial system.

The traditional classification of Taosi burials relied on the principles of labor input to attain vertical social stratification (Miyamoto, 2005); however, an excessive focus on social stratification ignores the possible horizontal social identity differentiation reflected in the burial pattern. While some burials included only jade and stone tools, others included more weapons. The original classification only defined these as differences in social hierarchy; however, such an explanation is not comprehensive or convincing. Such a classification does not provide a comprehensive picture of possible burial behavior and horizontal social differentiation. Different social groups may have different attitudes toward death and burials, and people may use different identity markers in mortuary practice based on their preference (Pearson, 1999). Therefore, the presence or absence of specific burial objects and the different tendencies observed in relation to the combination of burial objects can express not just social rank but also different social identities. The classification requires an approach capable of considering more horizontal differentiation than the traditional top-down approach.

In the face of large internal variation among Taosi burials, a multivariate analysis could contribute to the investigation of the potential markers of different social groups and provide a more comprehensive classification (VanPool and Leonard, 2011). Factor analysis can assess all burial attributes as a whole and examine the potential relationships that exist among all variables in an integrated mortuary manner. Further, combining this with cluster analysis can effectively classify the burials according to different potential relationships among variables.

Table 11 The preparing test of Factor Analysis (1) the correlation between various mortuary attributes; (2) the result of KMO and Bartlett test

	area	total burial objects	jade	pottery	woodware	lithic	bones	musical instrument	drinking vessels	serving vessels	lithic YUE	jade YUE
area	1	0.645	0.42	0.745	0.663	0.453	0.16	0.61	0.632	0.594	0.217	0.389
total burial objects	0.645	1	0.403	0.633	0.838	0.906	0.563	0.64	0.558	0.639	0.213	0.516
jade	0.42	0.403	1	0.179	0.262	0.295	0.034	0.38	0.171	0.162	0.18	0.737
pottery	0.745	0.633	0.179	1	0.817	0.313	0.178	0.453	0.872	0.865	0.064	0.329
woodware	0.663	0.838	0.262	0.817	1	0.6	0.377	0.526	0.677	0.92	0.174	0.37
lithic	0.453	0.906	0.295	0.313	0.6	1	0.465	0.565	0.301	0.325	0.218	0.413
bones	0.16	0.563	0.034	0.178	0.377	0.465	1	0.259	0.111	0.278	0.069	0.146
musical instrument	0.61	0.64	0.38	0.453	0.526	0.565	0.259	1	0.358	0.327	0.144	0.361
drinking vessels	0.632	0.558	0.171	0.872	0.677	0.301	0.111	0.358	1	0.653	0.018	0.37
serving vessels	0.594	0.639	0.162	0.865	0.92	0.325	0.278	0.327	0.653	1	0.089	0.247
lithic YUE	0.217	0.213	0.18	0.064	0.174	0.218	0.069	0.144	0.018	0.089	1	0.14
jade YUE	0.389	0.516	0.737	0.329	0.37	0.413	0.146	0.361	0.37	0.247	0.14	1

(1)

KMO and Bartlett test		
Kaiser-mayer-okin measure of sampling adequacy		0.764
Bartlett's test of sphericity	Approx.chi-quare	1580.689
	df	45
	Sig.	0.000

(2)

Factor analysis extracted two common factors (whose eigenvalue values are larger than 1) from the burial sample, explaining 50.46% and 16.63% of the relationship among variances (Table 11, showing the valid result of FA). After rotating the factors and eliminating relatively uncorrelated attributes (Table 12), it was observed that Factor 1 embodied mainly indicators of labor inputs, such as area and wood vessels for eating and drinking functions. Therefore, factor 1 is likely to depict the tomb owner's financial power and their ability to feast. Factor 2 contains variables with special functions, such as jade and musical instruments. Further, the area factor has been included in Factor 3, indicating a relationship with labor input. Jade and musical instruments from Neolithic China were considered symbols of power in Neolithic China. Most noble burials were accompanied by musical instruments or large amounts of jade to represent their political nobility or religious status (He, 2018; Liu and Chen, 2012). Therefore, Factor 2 could represent superiority in the realms of politics and religion.

Table 12 The factor scores of Factor Analysis

Rotated component matrix		
	Factor	
	1	2
pottery	0.857	
woodware	0.857	
area	0.718	
Total burial objects	0.649	0.542
jade		0.85
Jade Yue		0.763
Musical instrument		0.65

On the basis of the factor scores for each burial, they were clustered. The study used the k-mean clustering method, and after several rounds of adjusting the number of clusters, 9 was finally chosen as the number of clusters. However, there were still problems after clustering, and further divisions were needed for groups with larger numbers of individuals. The final grouping result is as follows (Figure 18):

Group A

This group has the highest factor 1 score value. This cluster is characterized as having the largest area and richest variety of burial objects and styles. Furthermore, the most obvious feature that distinguishes it from other types is the presence of musical instruments. These also included a large number of weapons and feasting-related vessels. As mentioned in previous studies, these burials belong to the rulers of Taosi society. The significant variance of the factor scores for group A implies people's different preferences, irrespective of their social class.

Group B

This group is characterized by extremely large Factor 1 values and relatively small scores for Factor 2. This indicates that group B is characterized by a large number of

pottery and woodwares, especially cuisine-related vessels, while other kinds of burial objects, especially jade and decorations, were rare. The members in this cluster belonged to the early period of Taosi society. These burials are also large. This group indicates that there was a group of elites in the early period who were honored with only feasting-related vessels. Within this group, it can also be internally divided into two subgroups according to the number of burial objects: B1 and B2.

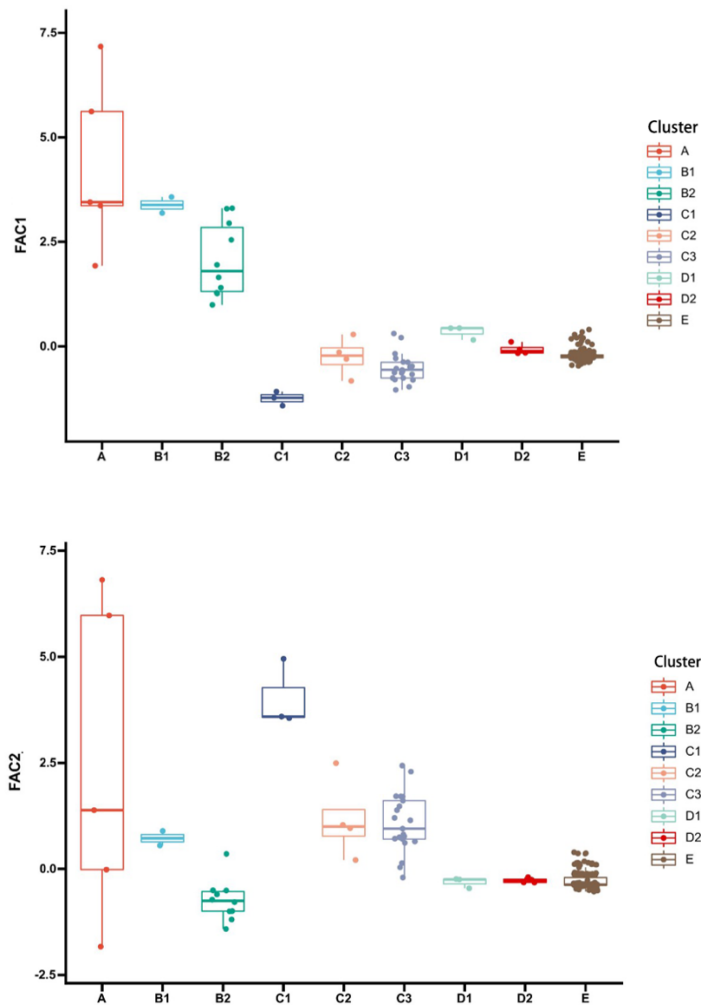


Figure 18 The factor scores of different groups

Group C

This group has obvious characteristics in terms of the orientation of burial objects: mainly burial jade and rare pottery and woodwares. That is, it has very high values of F2 and low values of F1. There are also obvious internal differences. C1 is a completely

buried jade, and the number of jade Yue is higher than the others in the group, representing a different hierarchy. Depending on the number and size of the areas, the rest member can also be subdivided into C2 and C3.

Table 13 The detailed classification of burials and social implication

Code	Estimated rank	Member	Evidence
I	ruler	A	The tombs are large in scale and there are many burial objects, all of which are most delicate and top-qualified
II-1	Head of the elite	B1	Large number of pottery and woodwares, large sized of burials, but smaller than
II-2	Upper-elite	B2	inferior to B1
	Upper-elite	C1	Strong orientation to jade, no pottery and woodware, largest number of jade Yue
III	Middle-elite	C2	Jade, existence of Jade Yue, fewer than C1
	Upper soldier	D1	Large number of weapon, mainly in the late period (according to report)
	Upper-Affiliated	E1	On both sides of the top tombs, the jade and pottery are exquisite, and the area is large
IV	Low-elite	C3	Jade items inside, small area of burial; some stone Yue replaced Jade Yue.
	Affiliated	E1	Simple one or two pieces of jade or pottery
	Low-soldier	D2	Small size with some weapon
V	Ordinary people	E2	Small size with some stoneware or bone wares

Group D

This group is mostly made up of weapons; Group D is also divided into two levels based on the number of weapons.

Group E

This cluster contains the largest number of burials, with F1 and F2 being of low value. This group contains burials of small size with a small number of burial objects (below 3). E1 and E2 were subdivided in group E.

The study of Taosi burials plays an important role in exposing the structure of Taosi social organization. The pyramid structure was also revalidated by the new grouping result. Combining the previous studies, groups A to E can correspond to different classes of society, as shown in Table 13. The top rulers of society are the masters of Group A. The secondary elite can be divided into three groups. The head of this elite group is group B1, with a higher status and appearing in an earlier period. They have a large number of pottery and woodwares but less burial object richness and quantity than group A. The rest of the secondary elite contains two groups of burial masters. B2 has a similar mortuary practice and ritual system to B1, but the quantity of burial objects and area are smaller than B1, while C1 also has a large area but does not have any pottery but many jades, representing and distinguishing the special status of the people from B1. Similarly, each social class may contain people with different identities.

Thus, in addition to the pyramidal structure, the classification in this paper also reveals a horizontal division of society. Different identities existed even within the noble classes, and they had begun to reinforce their identity characteristics through the different combinations of artifacts buried in the tombs. The different classifications of burials attest to the more complex social structure of Taosi society. Furthermore, the social structure of Taosi also produced great changes from the early to the late period (Table 14), mainly in the weakening form of social stratification and the disappearance of the top elite burials. Since fewer burials were found in the middle

period, further exploration is needed in the future to understand the structure of the middle period society.

Table 14 The number of ranked burials in the early and late period in Taosi cemetery.

	Early	Late	Unclear
I	5	0	0
II	13	2	0
III	16	3	4
IV	1	3	28
V	13	21	120

4.2.4 The Social system of Taosi society

Based on the above studies of settlement patterns and mortuary practice and combined with the previous studies, the social system of Taosi has been understood to a certain extent. In terms of social organization, Taosi society had a pyramidal social structure. The ruling elite accounted for a minority of society, while the ruled occupied the majority of it. Therefore, the whole Taosi society is a hierarchical society with obvious stratification. Although the internal divisions are obvious, the early as well as the late period burials are in a common graveyard, and the orientation of the graves has not changed for the whole Taosi period (Dai, 2019), proving their recognition of a common identity. Such a communal burial area, particularly in the early period, also suggests that the Taosi society's pyramidal structure was formed based on a common blood identity, which was a common social organization pattern in Neolithic China (Dai, 2019). The cemetery has also been carefully planned to form multiple rows. Each row corresponds to a gender or a different social status (Zhongguo et al., 2015c). This strict arrangement illustrates the strong social order based on the strong consciousness of blood ties. Besides the common cemetery, the household is also the basic unit of the whole society. The common residential areas are scattered in the northern and central parts of the site (Zhongguo et al., 2015). Houses were found in these residential areas, as were different tools for agricultural and craft production around the houses. It shows

that these livelihood activities are probably based on household units. Taosi society had a social organization structure based on household units, with common blood as a strong bond and social stratification, especially in the early period.

Along with such an organization pattern, it is clear that the politics of Taosi society were controlled by the elite group, which was powerful in both economy and ideology. The elite rulers controlled the majority of the society's resources. The storage facilities in the southern district—possession of the surplus materials of the society and possession of a large number of burial goods in the tombs, including rare items such as crocodile bones exchanged over long distances—indicate that the early elite also held the power of long-distance exchange (Dai, 2019). And, as political power became more concentrated in the middle period, the personalities of the rulers became more visible, with a separate graveyard from the commoner. From the early to the middle periods, there was also a process of political power centralization, as evidenced by the construction of the so-called palace area in the heart of District 1. The late period witnessed the collapse of political power.

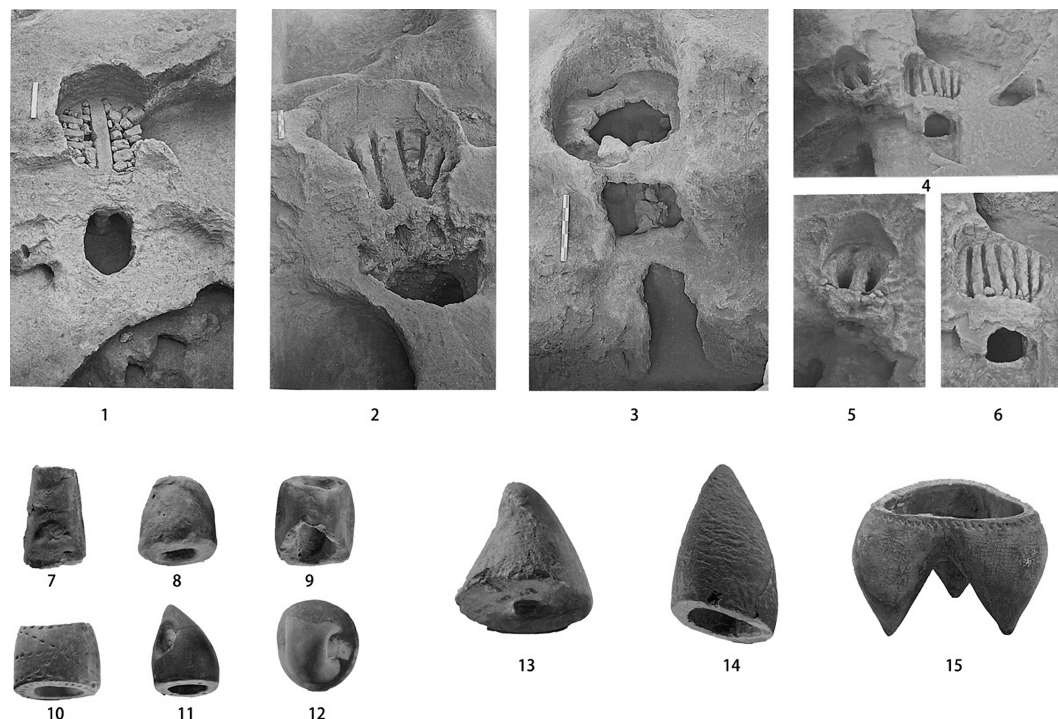
The ideology was also controlled among the elite group, and a common ideology and ancestor worship were maintained through funerary rituals. The compliance and recognition of mortuary practice are also evidenced by the fact that the commoners were largely scattered in the northern and southern parts of the site, away from the burial areas.

4.3 Pottery production system in Taosi site

In the following section, the pottery production system of the Taosi society will be analyzed through three dimensions: including a spatial analysis of the direct evidence, an analysis of the pottery standardization, and an analysis of the exchange and consumption patterns of the pottery in different scenarios. In addition, the study pays special attention to the painted pottery excavated from the burials to discuss about the production of luxury pottery in Taosi society.

4.3.1 Direct evidence: craft landscape of pottery production in Taosi site

A total of 28 pottery kilns were discovered in the Taosi site, distributed in different residential and functional areas, of which 11 kilns have detailed pictures and descriptions (Zhongguo et al., 2015c). Aside from that, the 56 tools, which include pottery pads (陶垫), models (陶模子), and knives (剔刻刀), are described in the published data (Zhongguo et al., 2015c). All these have provided very important evidence for the pottery production technology and organization of the Taosi site (Figure 19).



1. Kiln Y312 2. Kiln Y314 3. Kiln Y315 4. Kiln Y404(left) and Kiln Y405 (right) 5. Kiln Y404 6. Kiln Y405 7. Pad H354:3 8. Pad T370④A:7 9. Pad H420:1 10. Pad J401:59 11. Pad J401:126 12. Pad 2H4:6 13. Mold 4C:4 14. Mold 4C:5 15. Mold J401:107

Figure 19 The kilns and tools found in Taosi site

A. kiln analysis

In late Neolithic China, the kiln was an important facility to fire the pottery. The kiln construction investment is higher, and the technical requirements for the potters are also very high. The kiln is time-consuming and difficult to transport when compared to other methods of pottery production. Therefore, the kiln is a vital element to figuring

out the location of production loci and distinguishing different pottery communities based on firing technology.

The basic structure of a ceramic kiln in pre-history China could be similar, including a fire channel—the passage that transports the flame—a combustion chamber—the fuel chamber—and a fire chamber—places for firing ceramic. Kiln Floor: place the ceramic; Kiln grates: a thicker spacer layer between the fire chamber and the kiln room. Fire holes are dug on the raw soil as a device to balance firepower (Wang, 2011).

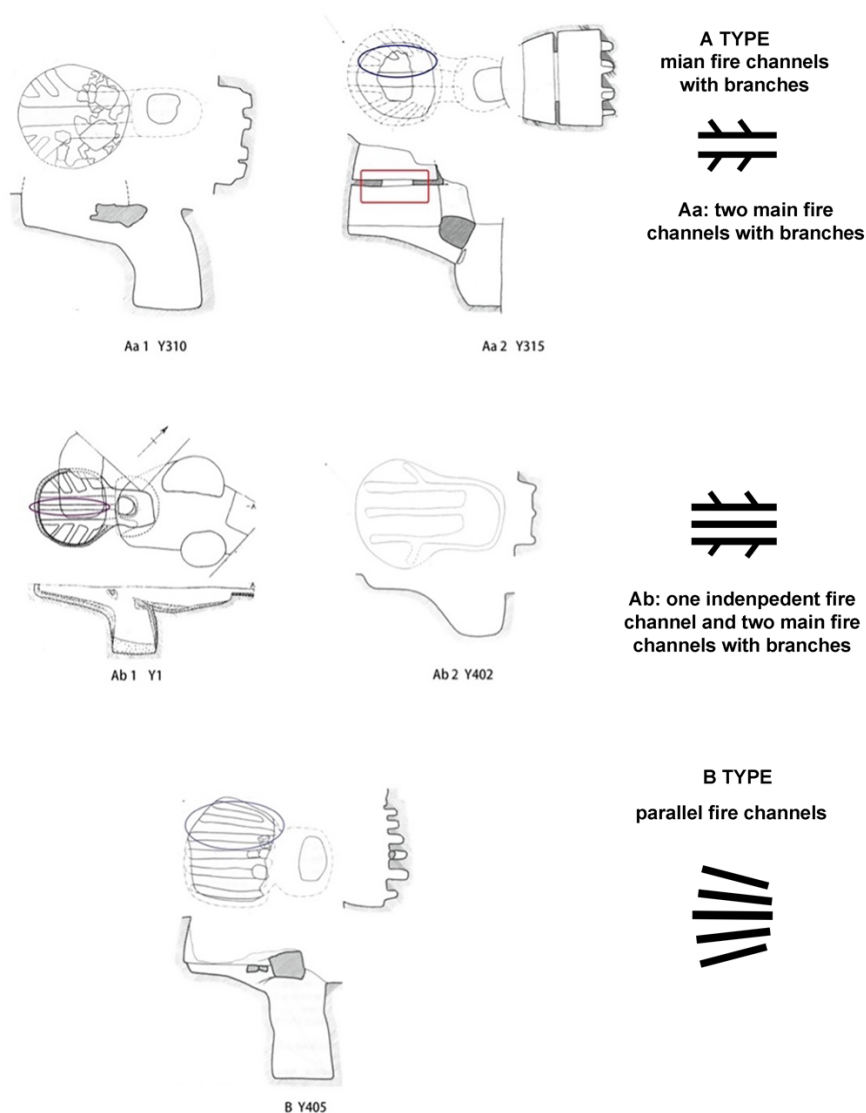


Figure 20 The structure and classification of kilns

According to the differences in the above structure, the research uses a typological method to classify them(Figure 20). According to the fire path, the Taosi site's kilns can

be divided into two categories: A type and B type. Type A's fire channels are composed of main channels and several sub-channels. The combination of the main fire and the branch fire channels can be divided into two subtypes. Aa type has two main fire channels, with branch fire channels distributed on each side—it evolves from a single-layer firing chamber to a double-layer firing chamber. A type has three main fire channels, of which the main fire roads on both sides have branch fire channels. Type B has parallel fire channels, and there is only one case found at the Taosi site.

In the early period, kilns were only distributed mainly in District 1's north part, showing similar structures. In the middle period, the kiln equipment has undergone tremendous changes, and parallel fire channels appear different from the early fire channels. Compared with the Ab1 type kiln, the flame was most likely to directly contact the pottery, which might lead to a decline in the ceramics' quality (Table 15).

Table 15 The location and period of different types of kilns

Classification	D1N	D1M	D2	D4
Aa1	Y312,Y310,Y314	02 Y3		Y404?
Aa2	Y315			
Ab1			99 Y1, Y2	
Ab2				Y402
B				Y405

(1)

	Early	Middle	Late
Aa1	—————		?
Aa2	———		
Ab1	———		
Ab2			—————
B		—————	

(2)

B. Physical location and spatial arrangement of production loci

The location of production facilities and tools, their arrangement and distribution in the production space and their relationship with other related landscapes are also an criteria for judging production systems and organizations.

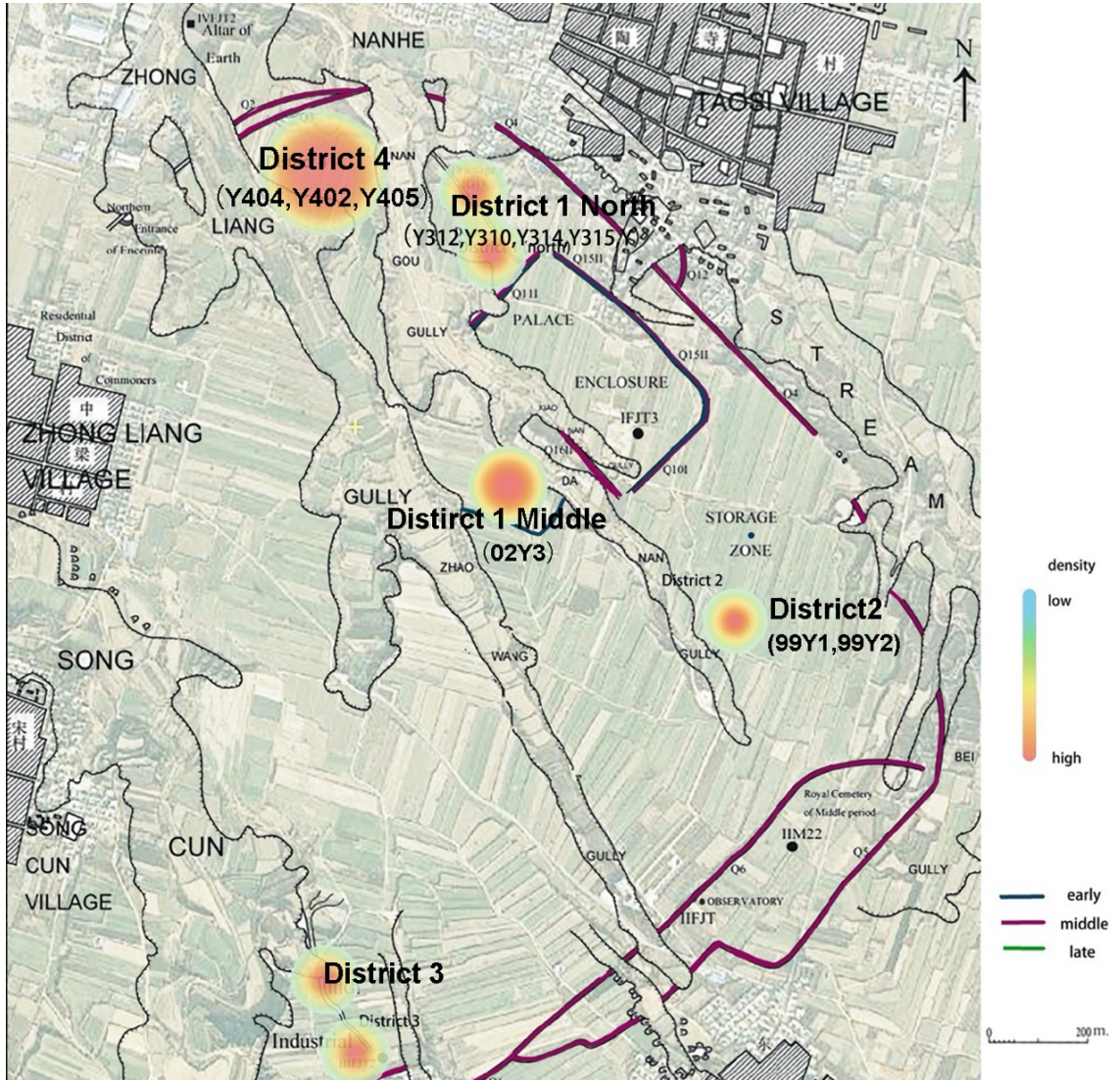


Figure 21 The density of kilns and tools of pottery production in Taosi site.

Based on the location of the pottery kiln and tools of potter production excavated, this study analyzed their distribution density throughout the site using the Map Lab in Gaode intelligent data platform(<https://maplab.amap.com>). The Figure 21 shows the distribution of the direct evidence in the Taosi site, demonstrating that the production units are very unevenly distributed in the Taosi site. Pottery kilns and pottery-making equipment are concentrated in the northern part of the site, especially in District 4 and

the northern part of District 1, which are located in the general residential area. The northern part of District 1 contains pottery kilns Y312, Y310, Y314, and Y315, all of type Aa, which belong to the early pottery period, and District 4 contains pottery kilns Y404, etc., which are type Ab and type B, which belong to the middle and late pottery period. In addition, some production remains are also distributed in the central and southern parts of the site, but the density is slightly less than the above two areas. The two pottery kilns found in District 2 are of Ab type, while no specific form data are available for the other areas.

More specifically, in the early period, the kilns and tools were concentrated in the district I area. In the north part of District 1, five kilns have been found (Figure 22). They can be clearly divided into two groups according to the distance between them and their surrounding houses, which may represent two different forms of production organization.

Group 1 contains 3 pottery kilns: Y312, Y313, and Y310, located in the southern part. This area is a concentrated residential area, including houses, stoves, and pits. Each of these three kilns is near houses and interestingly corresponds to a certain house, forming a combination: Y312-F318; Y313-F342 and Y310-F310. In addition, pottery production tools (pottery pads, stone pestles, and bone knives) were found within 5 meters of the house and kilns, indicating the forming and firing activities could be finished within the small area around the houses. Besides that, the pottery-making tools and equipment in this area were always mixed with tools for agriculture and other craft production, such as lithic and bone tools (Figure 22). It could be assumed that these activities probably share the same space and could be conducted at the household level. Such multi-craft production is a typical subsistence form in pre-history households (Hirth, 2009). Therefore, group one may represent household-level pottery production units. The structure of the pottery kiln and the type of pottery pad are very similar, which proves that they may share similar production technology. Group 2, found in the northern part, has shown a different form of organization. Two pottery kilns (Y314 and Y315) were found in the group. The location of these two kilns is a relatively separate space from the household. Around the kilns, the large water wells have also been found

to support possible pottery production (J301). There are no residential houses or other traces of daily life around here. There is a certain distance between this pottery-making area and other residential houses. The nearest house also has a blank of more than 15 meters. Such relatively independent equipment and space can give production more space for various divisions of labor.

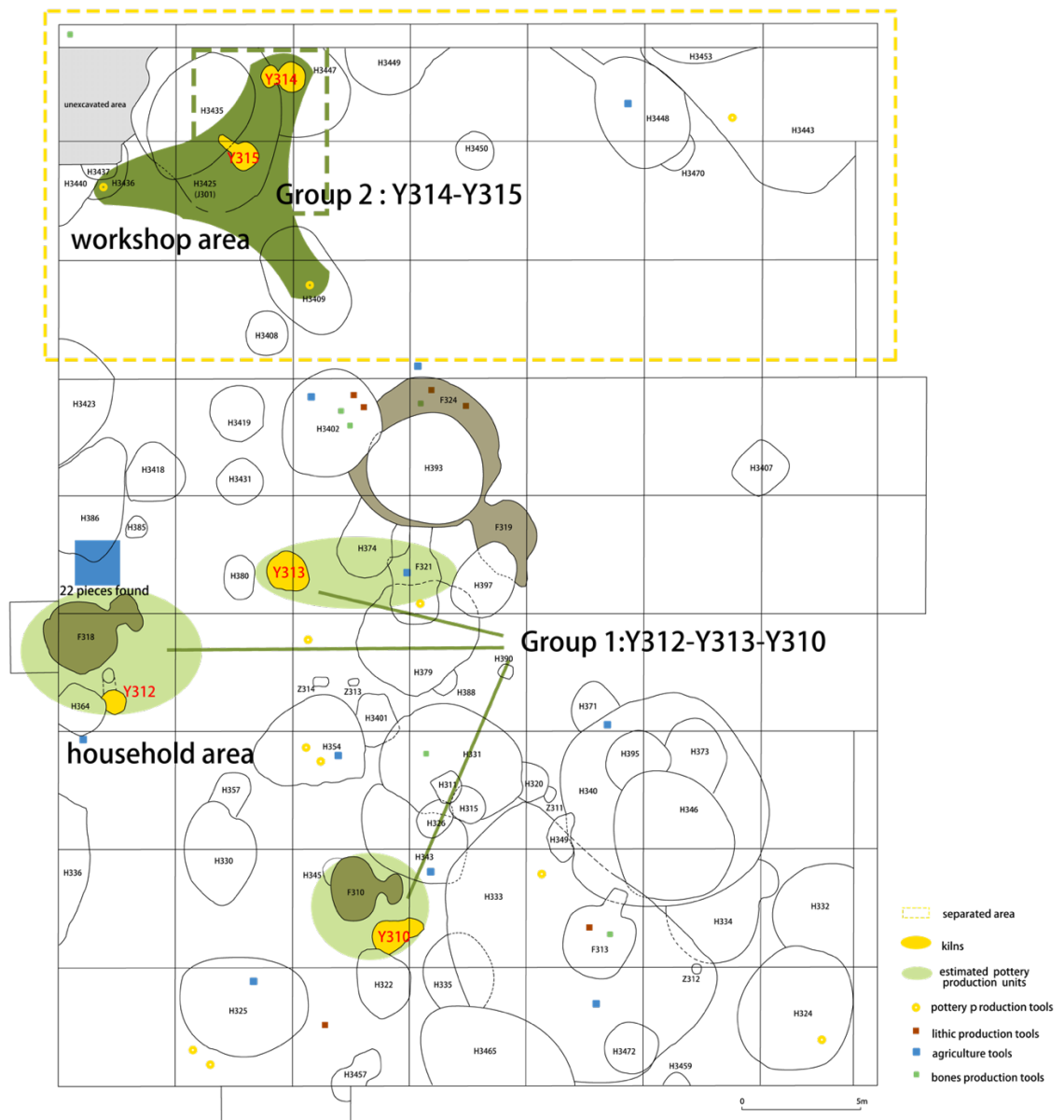


Figure 22 The arrangement of kilns and tools in the District 1 North

The development of the structure of two kilns also indicated the technological investment in these production units. According to the layer information, Y314 is earlier than Y315. The only difference between the two kilns is that Y315 has evolved into a double-layer kiln room so that the pottery can be stacked on the two layers. (Li, 2017).

Such a change enables a large increase in output. The behavior of improving the structure of the kiln in order to increase production has been sharply different from that of Group 1, which implies that production has exceeded the needs of daily life and Group 2 is likely to be a relatively specialized production unit. Besides that, within the north section, no remains other than pottery making activities were found. This distinction shows that this area may be dedicated to the production of pottery, which also implies a possible specialized organization.

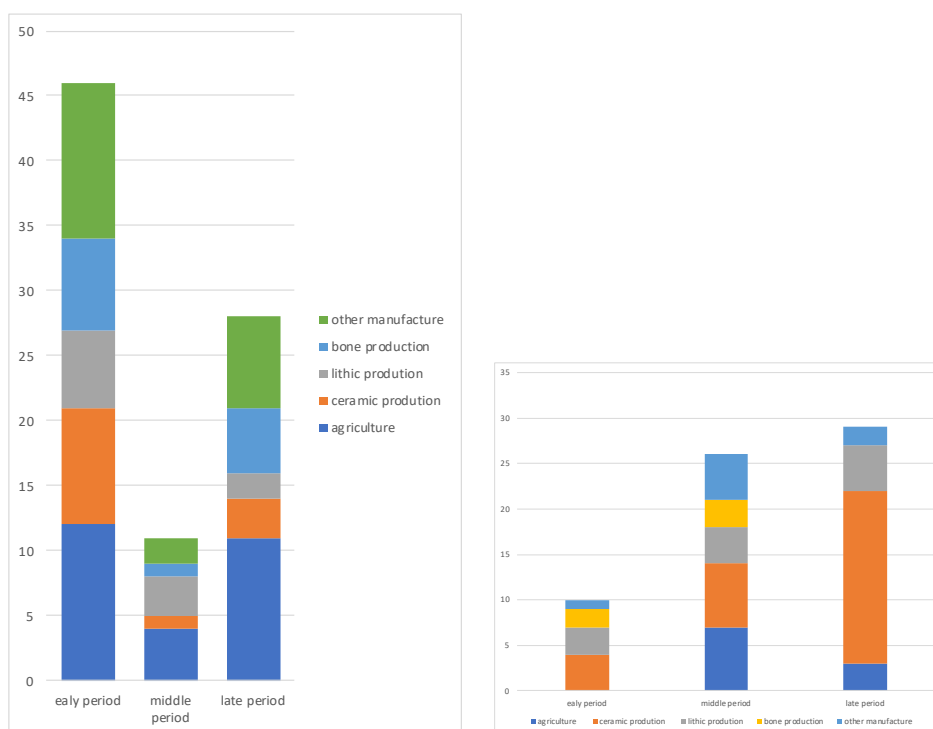
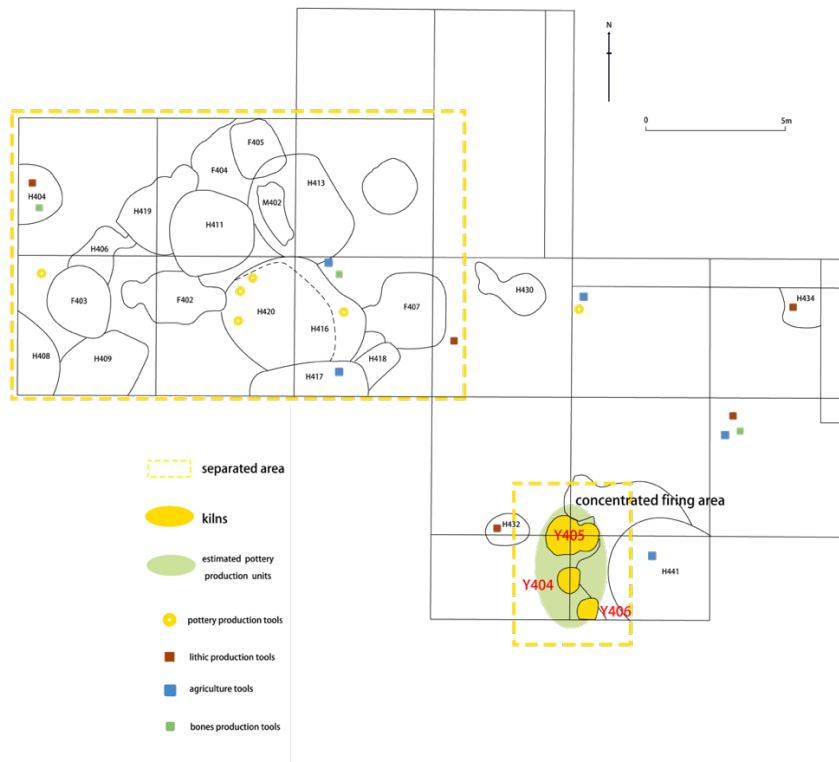


Figure 23 The proportion of different tools in the District 1 and District 4

Besides District 1, some pottery tools were found in other areas: 2 kilns in District 2 and a small number of tools in District 4 (Figure 23). They were scattered and had little description, so it is assumed that although pottery was made in other areas, the scale was small. Such a production organization could be regarded as household-level and self-sufficient production.

In the middle and late period, one kiln concentrated area is located in District 4. Three kilns (Y404, Y405 and Y406) have been found, and they are concentratedly distributed separate from the house area (Figure 24:1). The kilns here have applied a little different firing technology with three firing corridors. At the same time, four pottery pads and a bone knife were found scattered in the house area. The pads are also

different from the ones in District 1, which indicates the different forming and firing technology and different potter groups than the early period potters' group.



(1)



(2)

Figure 24 The distribution of kilns and tools in District 4 (1)middle period;(2) late period

Furthermore, the interesting thing is that the kiln area and the house area are separated by more than 10 meters. It proves that the forming process was conducted in the house area separately and firing activities were conducted in the other concentrated area. In addition to pottery tools, other agricultural tools and stone tools were also found in the house area, proving that pottery production is a part of subsistence activity, which has been argued as a multi-craft production model in the early period.

Such a pattern has also been found in modern Yunnan and Guizhou provinces in China (Wang, 2003; Underhill, 2002). This is argued by Chinese ethnologists as a kind of "cooperative" firing model, which is a collective production behavior within the community (Wang, 2003). In the ethnographic survey of the Dai ethnic community (傣族) in Yunnan, the kilns were concentratedly located outside the living area in order to prevent fire. In this case, the kilns can be used in rotation among the community, and the pottery production is a part-time job in every household. Under this model, the total scale of production is small, and the degree of specialization and production efficiency is relatively low because it is still based on the household community. Based on such examples and analysis, the production model in this area could be household-based and contain basic cooperation and labor division among the community (Underhill, 1996).

With the collapse of the political power in Taosi site, however, conversely, the independent pottery production has received little influence from the such social turmoil. In this period, the specialized pottery organization developed from the previous production. Three kilns: Y401, Y402 and Y403 were found in District 4 and they were concentrated in the center of the area (Zhongguo et al. 2015c). The kilns structure and pads are similar to the previous ones, such similarity may indicate the same technology tradition. And there were innovations and applications of pottery-making techniques in this period. Pottery molds were found centrally for making the legs of tripod vessels (Li, 2017). It shows that the potters invested time and effort in the production (Figure 24:2).

This area has also shown a clear spatial arrangement of a workshop. The area

where the 3 kilns are concentrated is the firing area. A long ditch (H425) was found near the kilns, which contained a large amount of slag-deformed pottery, containing pots, basins, cups, etc. Apart from this, pottery production tools and animal bones, especially divination bones, have also been found in the ditch. Apparently, the ditch is a special place for stacking production waste. The deformed pottery shows that this pottery production unit produces a variety of products. It is not a specialized production of a single product. At the same time, the animal bones may represent a traditional divination ritual activity. In the Neolithic and Bronze Age of China, animal bones are connected to divination, sacrifice, and feasting activities, which may enhance social power, reinforce specific identities, and communicate with the spiritual world (Chang, 1983; Liu, 2003). The pattern concentrations of divination bones in artisan areas have also been found in the Yinxu site. Such a pattern was explained as communication with the metaphysical world and a desire for positive production outcomes (Reinhart, 2018). The same discovery of divination bones in Taosi may also illustrate the possibility of ritual activities and the importance of these pottery production activities. In addition, there are wells adjacent to the long ditch that provide the necessary water source to produce pottery. A large number of pottery tools were also found around the kilns and the ditch (Figure 22:2). There is no residential house found in the entire area and only a few lithic production tools were found around pottery making tools, indicating the entire space could be special for pottery production. In this case, there is enough space for every process of pottery making and storage for the semi-finished or finished product. Therefore, the units found here could be regarded as a specialized pottery production "workshop."

In addition to this, there is a controversial area of pottery production activities in the middle period (Figure 25). This area is located in the southwestern quadrant of the site. It is regarded by the excavators as a specialized workshop area controlled by the elite and only existed in the middle period (He, 2018). The layout of the entire production zone is composed of six regions (He and Gao, 2018): two stone-making industrial areas, two pottery-making areas, and two-house concentration areas. Due to the limitations of published materials, it is impossible to know the internal structure and

specific pottery kiln structure, as well as the tools and products. Only the layout of the entire workshop area can be known.

There were 10 kilns found in this area, and they are divided into two ceramic production areas, and the southern part is considered by the excavators to produce luxury color-painted ceramics for the elite (He and Gao, 2018). Around this area, there was a large building (Q6), regarded by the excavator as the management office of the elite, proving that this production was controlled by the elite. If this assumption is true, then this area may especially serve the elite and could be an attached organization (He, 2018). Furthermore, there are five pottery kilns in the northern area. This group may be used to produce general pottery, supporting all production activities and providing a home for the craftsmen. There are not many large buildings around this area, and it is close to the small house concentration area, which proves the status of this group is relatively low. Throughout the craft workshop area, residential houses and tombs were found in the area. It may prove that potters or other craftsmen have lived here for generations, producing pottery and lithic products for a living and being buried here after death. It is assumed that there could be full-time potters sponsored by the elite.

However, all information is the excavator's own description and there is no an official report on this area. Since the specific data of the production facilities and production have not been published yet, the specific production organization form is not clear as well. That is, the excavators' conclusion that it was an attached production organization remains unproven and needs to be further explored later with the release of archaeological data.

To sum up, based on the examination of direct evidence of pottery production, we can know that production units of different scales existed in different areas of the Taosi site and were not evenly distributed and developed. In the early period of Taosi, production units were distributed mainly in commoner residential area, mixed with other production activities. Until the middle period pottery production units still existed in settlements with a form similar to community cooperation. By the late period, the work units in the commoner context in the District 4 with concentrated work place and dedicated ditch for production trash may be the specialized workshop for pottery

production, but more evidence is needed to prove it. Although it can be seen that the organization of pottery production in the Taosi society may have varied in the three periods, the discussion about the pottery production in Taosi society mainly focuses on the situation in the early period due to the fact that the pottery data in the research is mainly from the early Taosi period.

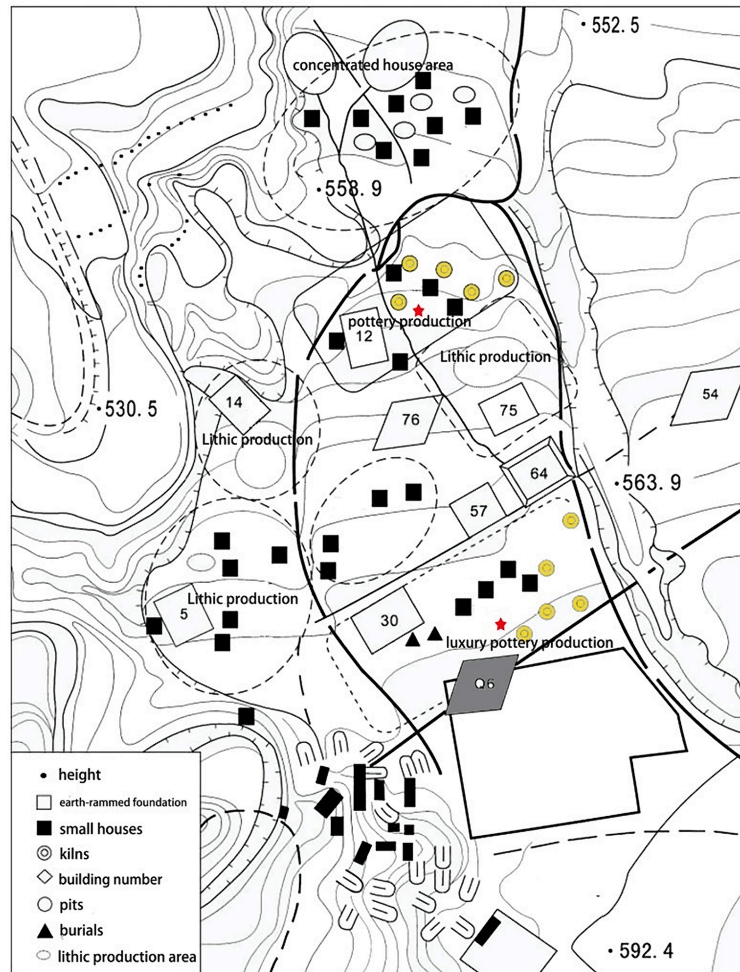


Figure 25 The arrangement of remains in District 3

4.3.2 Indirect evidence: the standardization and differentiation of pottery in Taosi site

A. Clay composition

Due to limited data access, this section of the study can only rely on the data published in the report and previous studies to examine the similarities and differences

of the clay in different contexts and periods using various statistical analyses.

Table 16 The chemical composition of different types of clay resource. Wang and Wang (2013)

Type of clay resource	SiO ₂ %		Al ₂ O ₃ %		Flux	
	average	range	average	range	average	range
	A ordinary plastic clay	<70 69.79	56.02- 68.12	<20	12.4-19.97	>11 17.01
B clay with high magnesia	<69 68.06	54.85- 68.06	<6	5.41-5.84	>22 32.93	22.91- 32.93
C clay with alumina	<69 68.12	56.19- 68.12	>20	20.57-35.56	<8 7.80	5.89- 7.80
D clay with silica	>69 71.72	69.89- 71.72	<22	15.84-21.98	<10 9.63	3.93- 9.63

Previous studies have summarized the basic chemical composition of soil in ancient northern China (Wang and Wang, 2013; Li, 2017) (Table 16). From the available data, the raw materials of the current pottery from the Taosi site are all type A clay: ordinary plastic clay. They also argues that the raw material of pottery is clay from the vicinity of the Taosi site.

Figure 26 demonstrates the different distributions of the clay chemical composition in different periods and contexts of use. The results illustrate a certain change in the composition of the pottery clay from the Miaodigou period to the Taosi period. Firstly, the Miaodigou period clay exhibits a high content of Na₂, compared to the Taosi clay. The late Taosi period have higher composition in FeO and K₂O compared to the early period. Moreover, even in the same period, the pottery used in the burials and in the residential area show some differences, with the SiO₂ in the burial pottery clay being generally lower than that of the pottery used in daily life, while the MgO content is higher.

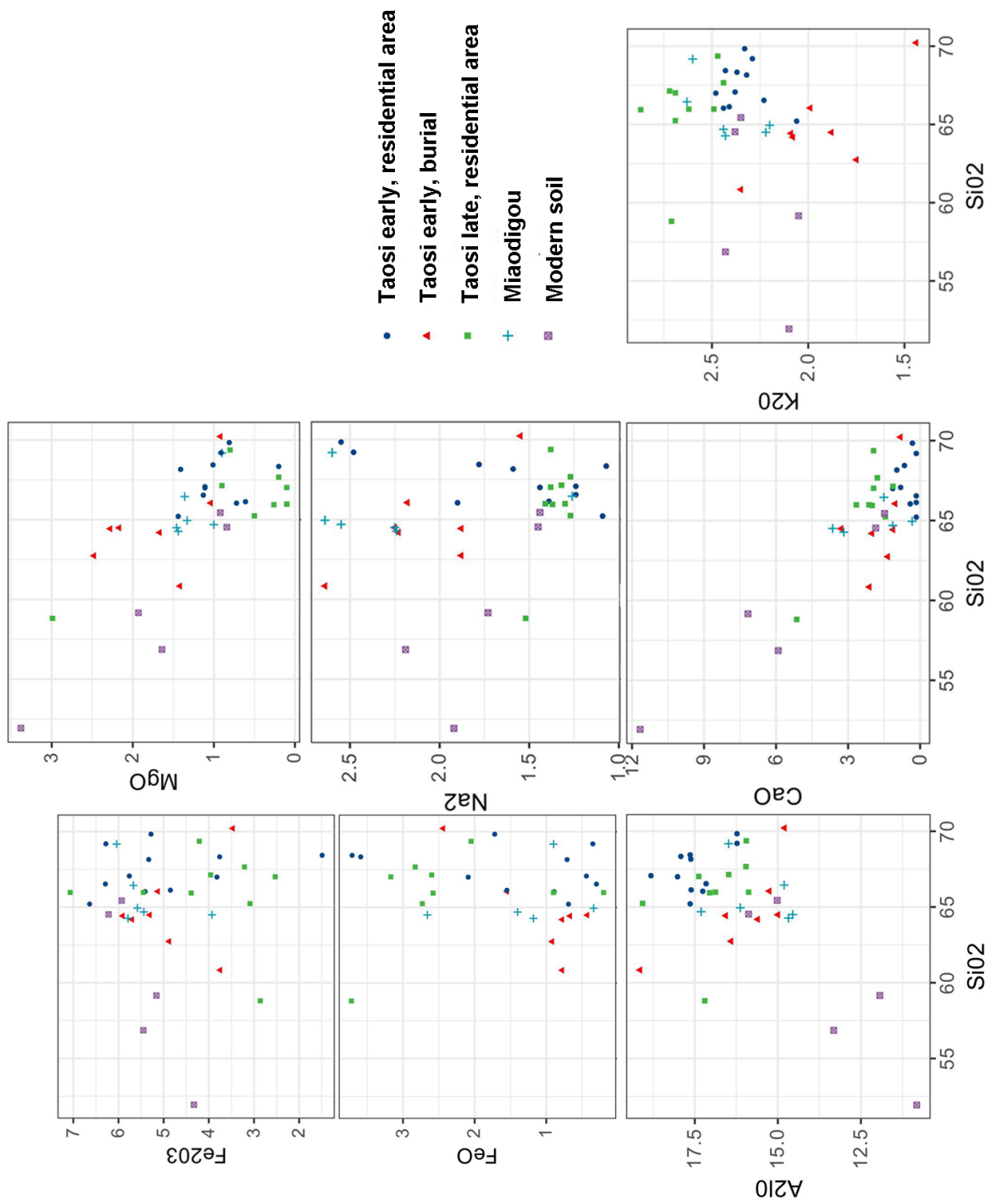


Figure 26 The distribution of main chemical component of clay from Taosi site

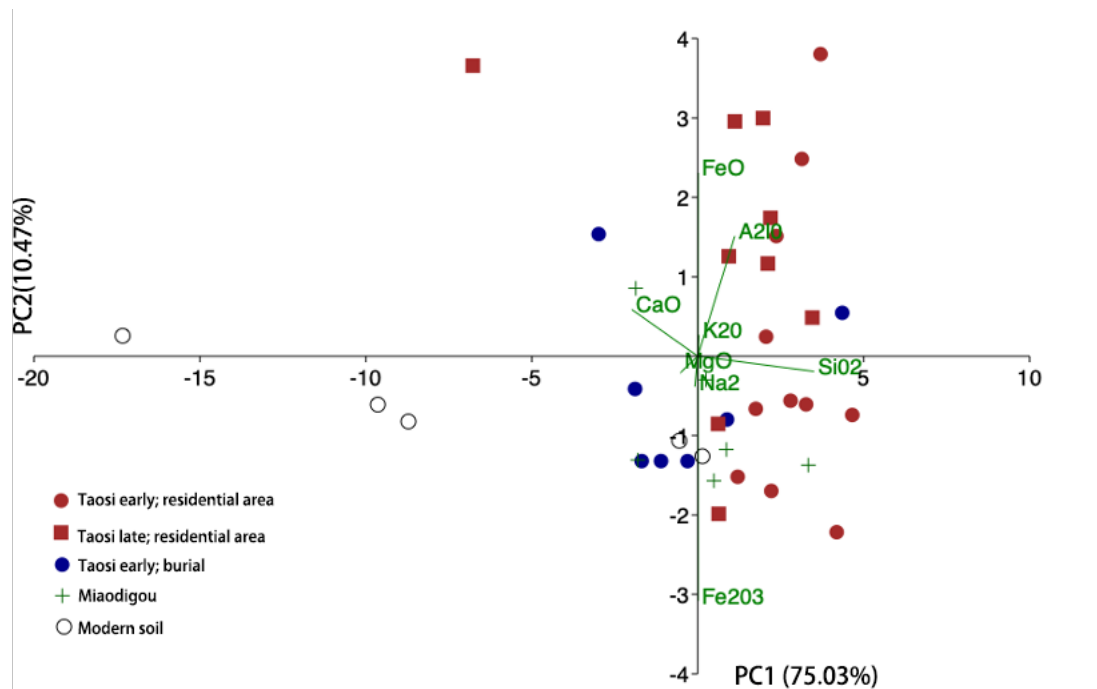


Figure 27 The PCA result of clay composition

Based on above result, the study applies principal component analysis to examine the overall variability of the clay composition. In principal component analysis, PC1 explains about 75% of the variation in the total clay composition and PC2 explains around 10% (Figure 27). The higher the PC1, the higher the SiO₂ composition of the clay, and the lower the CaO. In addition, a higher PC2 indicates a higher content of FeO and Al₂O₃ in the clay, and a lower PC2 indicates a higher Fe₂O₃ content of in the clay. The composition of the pottery showed significant differences from some modern soil samples. Among the clay samples, the clay of the Miaodigou samples forms a clear aggregation, characterized by the high inclusion of Na₂ and Fe₂O₃, while the pottery samples from the Taosi period vary to a greater extent. Within the Taosi period group, the burial pottery sherds have less variation than those from the residential area, and although there are some overlapping samples between the burial pottery and utilitarian pottery, the burial one is more inclined to contain more MgO and CaO.

The MANOVA test results in various temporal and spatial contexts show that there is a significant difference between the pottery excavated from the residential pits and the burials (Table 17), indicating that the pottery used in the burials may have been produced specifically for the mortuary behavior. While there is no difference between the early clay and the Miaodigou period clay, there is a difference with the late period,

indicating a change in the clay.

Table 17 The MANOVA test on clay samples in different context and period

	early	Miaodigou	late	modern
Early				
Miaodigou	0.054			
Late	0.002**	0.245		
Modern	0.000 ***	0.565	0.174	

(1)

	Burial	Residential
Burial		0.0014**
Residential	0.0014**	

(2)

To conclude, combined with previous studies, it is shown that the raw material of Taosi pottery was mainly from the soil near the site, and different ingredients were adjusted to produce everyday utilitarian pottery and burial-specific one according to different consumption contexts.

B. Morphological and metric analysis

The morphological and metric attributes of pottery are the most intuitive attributes of pottery. Variations in shape and size attributes can be used to determine differences and similarities in molding techniques, differences in production groups, and particular production intentions.

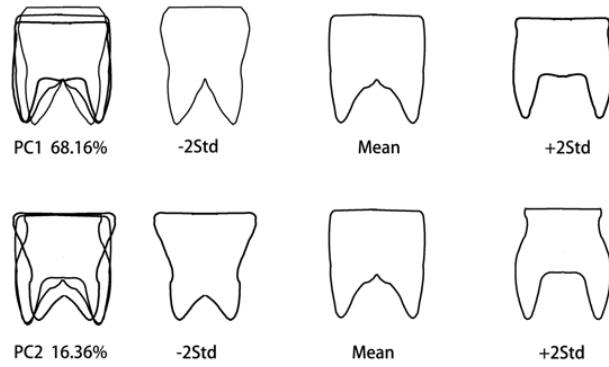
The excavation context of the pottery provided a potential social identity of its users, according to the dynamic settlement changes discussed above. Based on the research on the settlement pattern changes and the mortuary behavior described above, it is first possible to divide the pottery into two main categories: the elite burial context and the commoner burial context. Pottery excavated in the northern part of District 1, District 4, District 2, and other general living areas can be considered to represent commoner pottery consumption. According to previous research, the middle part of

District 1 was the elite's living area during the middle period (He, 2018), so the Jars and Dou discovered in this area were most likely used by the elite in their daily lives. However, because almost no complete pottery was discovered in this area during the middle period, it was not included in the sample for this study. In addition, the pottery in the burial context can represent different ranks of the elite. The Taosi structure has a special mortuary custom: only the elite were buried with pottery; therefore, the pottery in the burial can show the consumption tendency of the elite. There is also hierarchical delineation among the elite groups. As shown above, a large amount of pottery was found in Group A and Group B burials, and the owners of these burials are the top and secondary elite groups, respectively. Therefore, the pottery from the burials in Group A represents the pottery consumption of the top elite group, and the pottery from Group B (B-1 and B-2) represents the pottery use of the secondary elite group. The figure uses T1 and T2 to divide the burials of the top nobility and secondary elite.

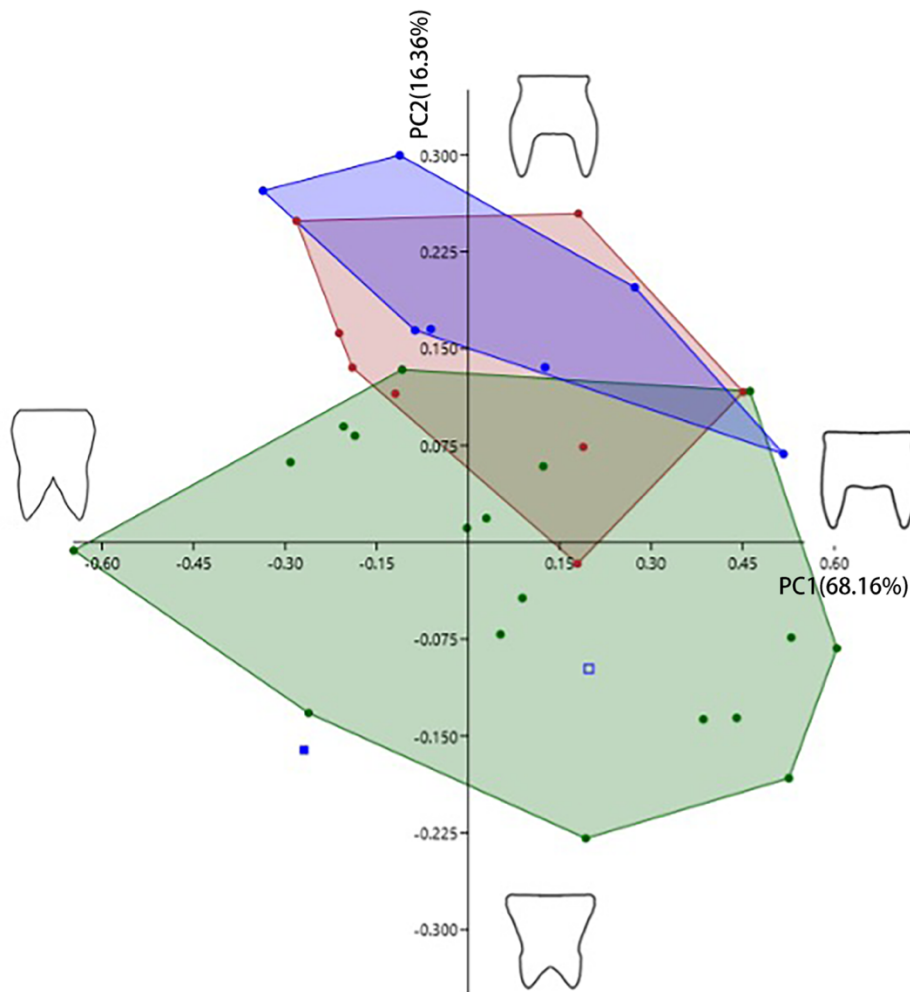
Cooking Jia

Jia is one of the common cooking vessels in the Taosi site and is found in both residential areas and burials. The principal components are abstracted by EFA. The first two principal components described nearly 85% of the total variation, with a proportion of 68.16% in PC1 and 16.36% in PC2. PC1 captures the change of the foot part, and PC2 mainly captures the change of the rim and belly (Figure 28).

The result of EFA shows that the Jia excavated from the burials has a greater degree of variation than it does from the common residential area. Especially in the samples from the secondary elite context, the values of PC2 are relatively small and have the largest variation. In addition, the samples from three groups in the early period show a large overlap, indicating that they possess a large number of similarly shaped Jia. The Middle and Late periods, on the other hand, have a small sample size but a different shape than the Early Commoner context.



(1)



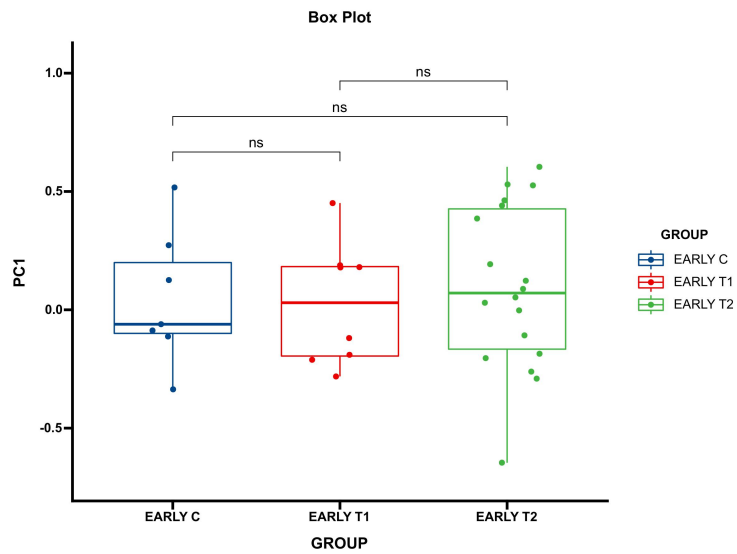
(2)

Red: I ranked elite burials(T1); green: II ranked elite burials (T2); blue(C): commoner residential area; Round: early period, solid square: middle period, hollow square: late period

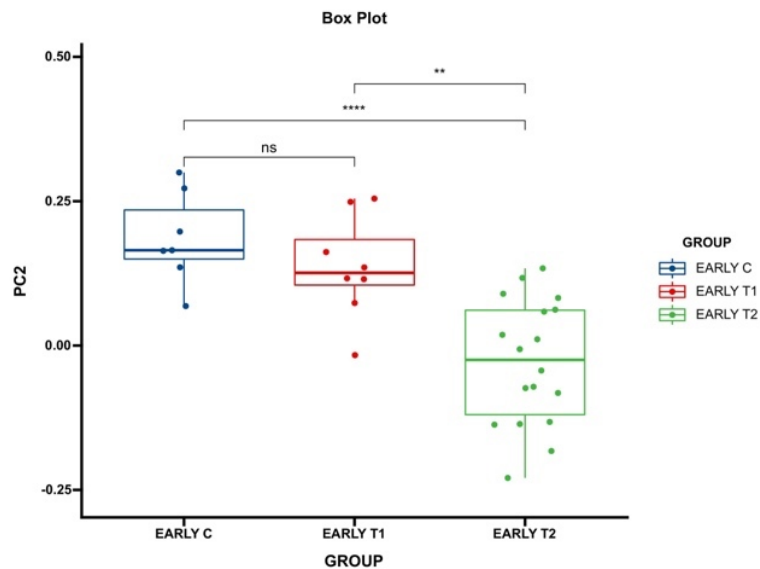
Figure 28 The result of EFA and PCA on morphological attributes of cooking Jia (1) the shape variation implied by EFA; (2) the PCA results of EFA

Separate ANOVA tests showed no significant differences between the commoner

and elite burials on PC1, with the greatest degree of variation in secondary burials and less variation in the commoner context (Figure 29). There is a wide range of overlap. PC2 also shows a similar picture in the variation tendency but implies the significant difference in secondary elite from the top elite and the commoner context. This situation illustrates that Jia in the secondary elite context possesses a tucked-in rim with a longer foot. The unique shape features are shown in many samples in this group, probably due to the different production resource.



(1)



(2)

T1: I ranked elite burials; green: T2: II ranked elite burials; C: commoner residential area

Figure 29 The distribution of PCA result and Anova result of cooking Jia (1) PC1; (2) PC2.

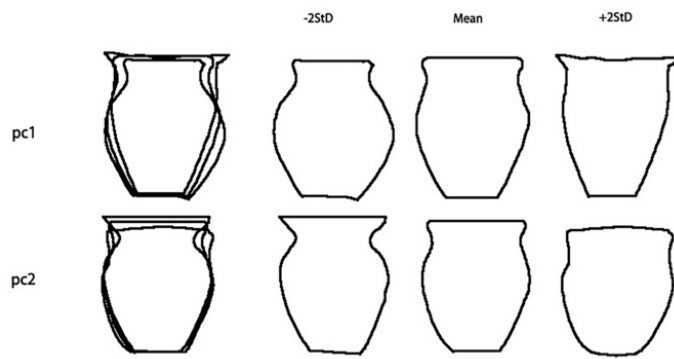
As for the dimensions, combined with a portion of the mouth rim fragments, CV presents large values in both burials and the residential area, with the top elite context having the smallest CV values. The CV of the secondary elite group is the largest, which is consistent with the results obtained from the shape examination (Table 18).

Table 18 The CV result of pottery in Taosi site

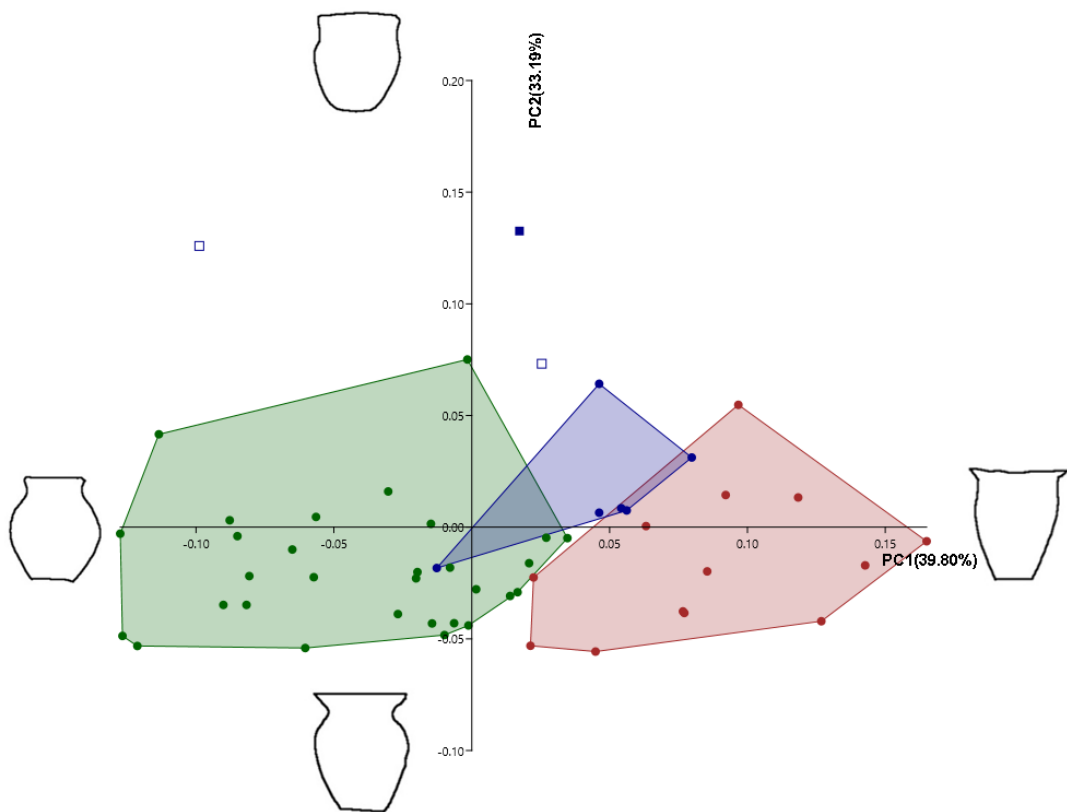
	STDEV.	Average	CV
Cooking Jia(N=50)			
Early commoner	3.79	15.3	24.76
Early t1	4.56	22.36	20.39
Early t2	7.53	22.34	33.73
Storage jars with large orifice(N=41)			
Early commoner	5.54	29.09	19.04
Early t1	2.77	26.56	10.43
Early t2	5.92	27.22	21.75
Serving Dou(N=68)			
Early commoner	11.07	31.99	34.6
Early t1	1.58	19.27	8.19
Early t2	1.45	15.73	9.2

Storage jars with large orifice

The jars with large orifices are found both in burials and in commoners' residential contexts and are mainly used in the early period. Only a few were found from the middle and late period.



(1)



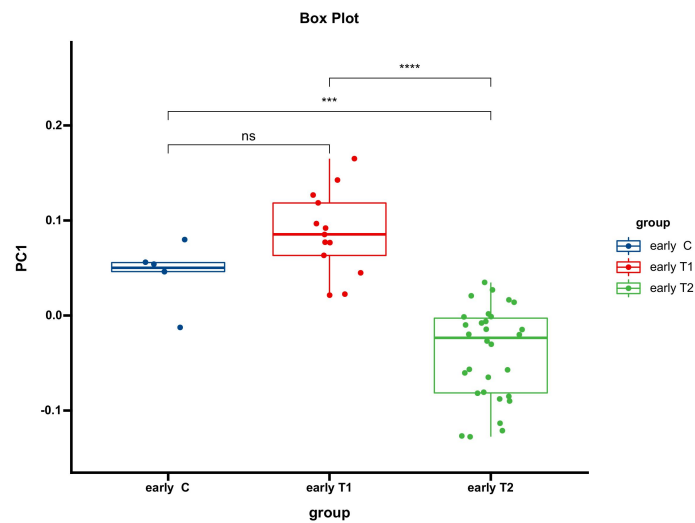
(2)

Red: I ranked elite burials(T1); green: II ranked elite burials (T2); blue(C): commoner residential area; Round: early period, Solid square: middle period, Hollow square: late period

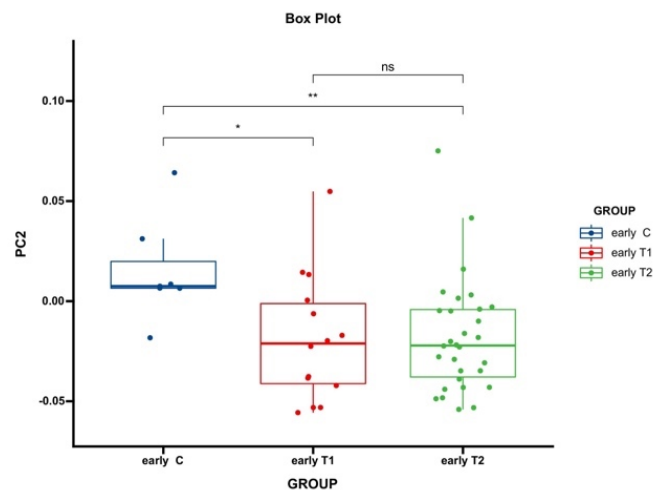
Figure 30 The result of EFA and PCA on morphological attributes of Jars (1) the shape variation implied by EFA; (2) the PCA results of EFA

The first two principle components described 72.99% of the total variation, with the proportion of 39.80% in PC1 and 33.19% in PC2(Figure 30). PC1 captures the change of the abdomen and rim and PC2 mainly captures the change of the rim. The results reflect that the jars from the top burials in the early period tend to have flat

abdomens and a larger rim than those in the secondary burials. The ones in the commoner context are located in the middle between the T1 and T2 groups. Furthermore, the jars from the middle and late period are more likely to show the features of smooth curves around the neck and have a small rim. The spread of the shape distribution implies a larger variation in the elite context than the commoner context. And the sample in the commoner exists in the part where the other two groups overlap, implying that the pottery has a certain similar shape (Figure 30).



(1)



(2)

T1: I ranked elite burials; green: T2: II ranked elite burials; C: commoner residential area

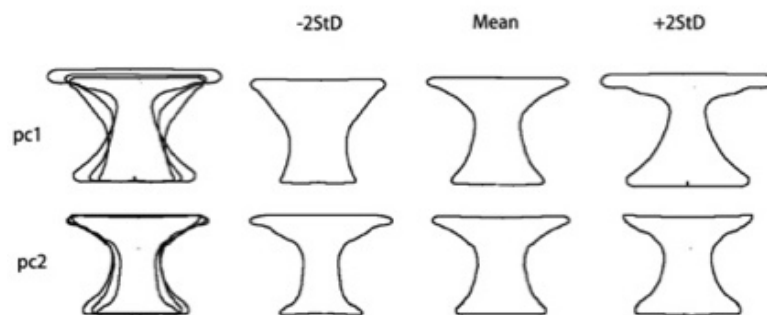
Figure 31 The distribution of PCA result and Anova result of Jars (1) PC1; (2)PC2.

An Anova test on each PC (Figure 31) shows that, in the top burials, the PC1 is larger than in the secondary burials, which means that the ceramics in the top burials have relatively flat abdomens with large orifices. As for the degree of variation, however, the jars in commoner contexts have less variation than those in burial contexts. The jars in the secondary elite context have the largest variation and show the difference between the ones in the top elite group and the commoner group. PC2 also shows a similar situation. As for the size measurements (Table 18), unlike the variability shown by the morphological attributes, the top burials have the smallest CV values and are the most standard of the three groups, in contrast, the variation of jars in the secondary elite burials is a little larger than in the commoner ones, which does not correspond to the differentiation in identity of the social rank.

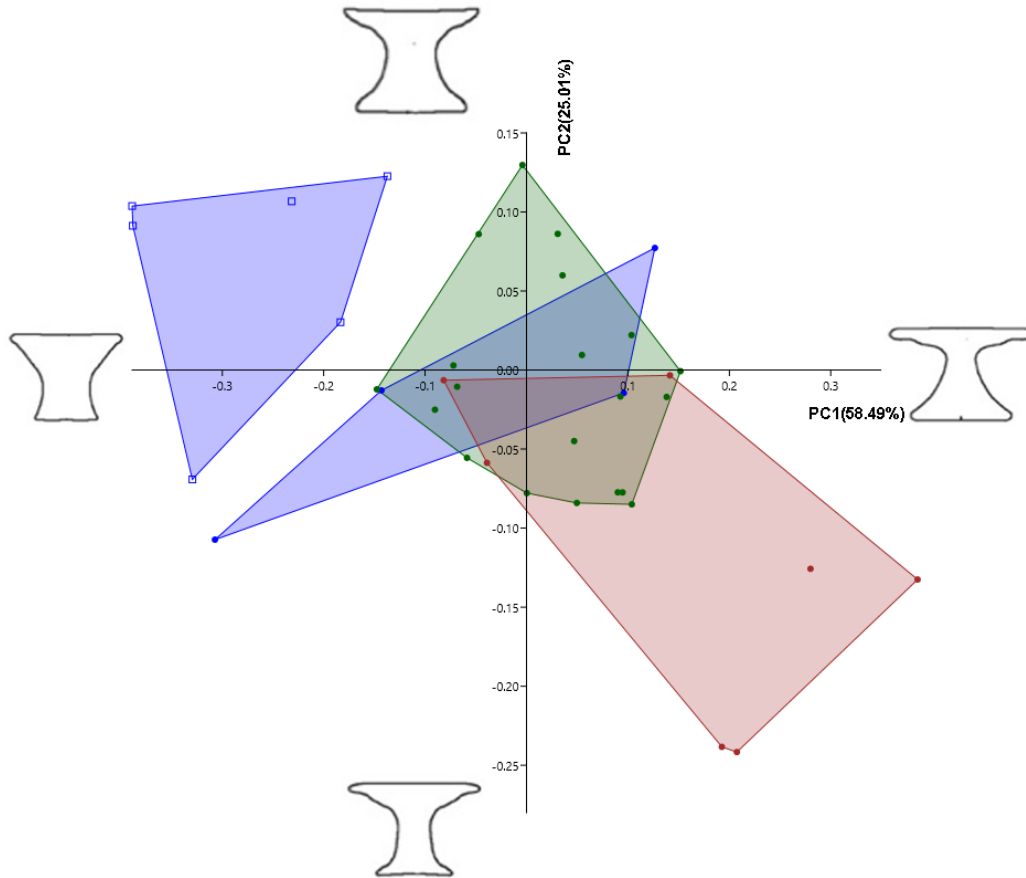
Serving dou

Dou are found both in burials and commoner residential contexts through the Taosi period. It is mainly used for food serving. However, the ones found in the middle period only appear in the palace area and are not complete in shape.

The first two principle components describe 83.50% of the total variation, with the proportion of 58.49 % in PC1 and 25.01% in PC2. PC1 captures the change in the upper part of the *dou* and its base and PC2 mainly describes changes in the edge of rim (Figure 32).



(1)



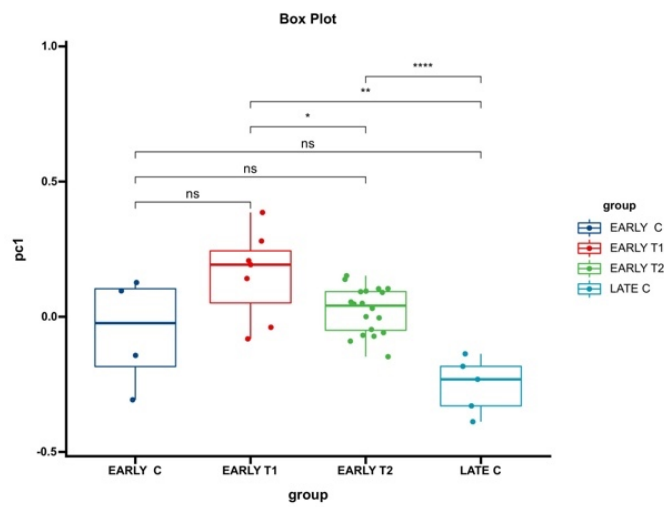
(2)

Red: I ranked elite burials(T1); green: II ranked elite burials (T2); blue(C): commoner residential area; Round: early period, Solid square: middle period, Hollow square: late period

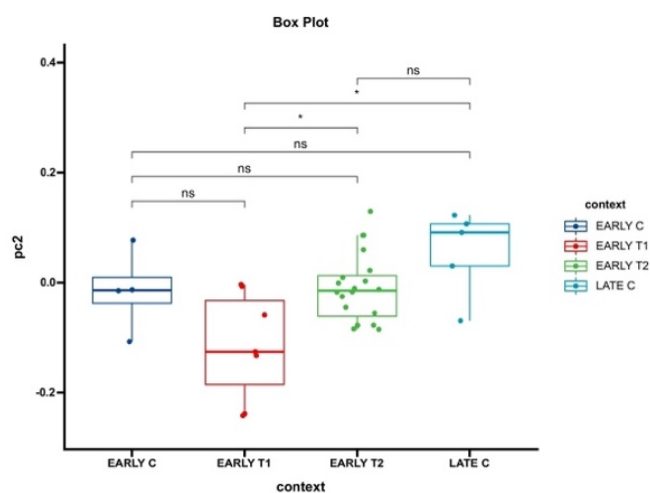
Figure 32 The result of EFA and PCA on morphological attributes of Dou (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The results clearly show a significant difference in shape between both early and late period. The late period Dou has a fewer value of PC1, meaning it possess a deeper belly and round neck. For the sample in the early period, the results reflect that there is a partial overlap between the commoners and the burial context, showing the similarity in the shape of dou between the top and secondary burials. And the shape of the samples in the burial context is more variable than those in the commoner context. But there is a separated group in top burials with an extremely high value of PC1 and shallow belly part. These samples are all from the same top burial, M2001, and these samples are clearly distant from the other early samples. This suggests that perhaps this burial deliberately pursued the differences (Figure 32).

The box plot shows the result of Anova test on each PC scores (Figure 33). There is no significant difference in PC1 between the early commoner context and the burial context, and a significant one appears in the late period. As for the degree of variation, although there is a large change in the early commoner context in PC1, the change in PC 2 is smaller than it in the burial context, but in the figure 32(2), the change area of the early commoner samples is slightly smaller than the burial samples, meaning the variation range of the commoner in the early period is slightly smaller than the burial context group.



(1)



(2)

T1: I ranked elite burials; green: T2: II ranked elite burials; C: commoner residential area

Figure 33 The distribution of PCA result and Anova result of Dou (1) PC1; (2) PC2.

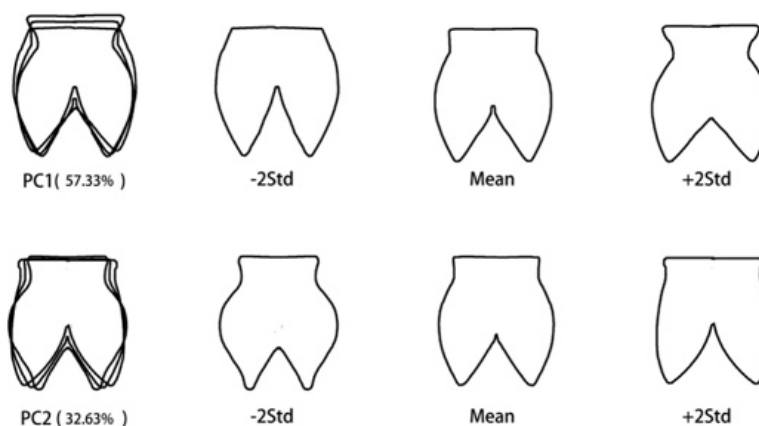
In terms of size, the rims of *dou* in the burials show a high degree of standardization. The top elite group has the smallest CV, whereas the commoner group has the largest one. Unlike other types of vessels above, the degree of variation represented by CV of Dou corresponds to the social rank: the higher the rank, the smaller the dimensional variation (Tabel 18).

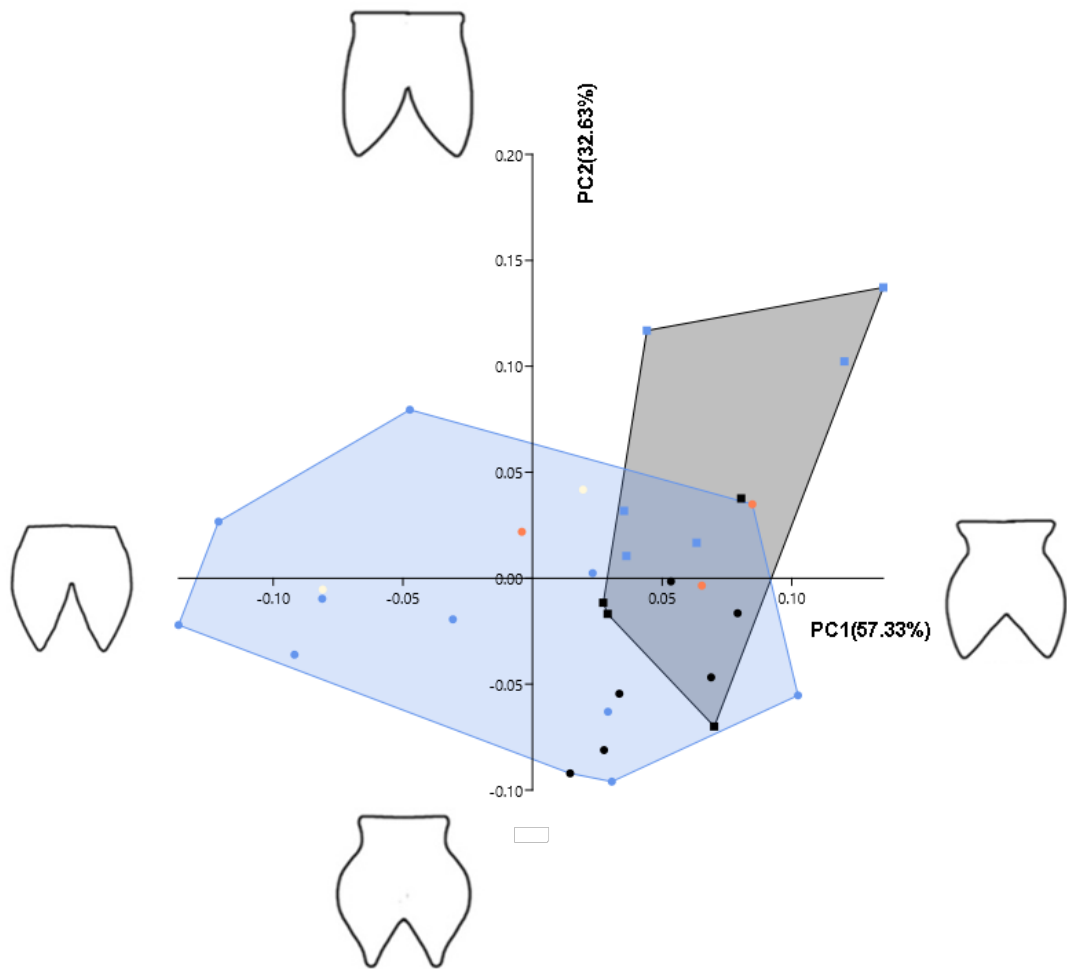
Cooking li

Unlike the pottery mentioned above, cooking li occurs only in residential areas in the middle and late period. It could represent mainly the use of cooking vessels by the commoner people.

The first two principle components described 89.95% of the total variation, with the proportion of 57.33% in PC1 and 32.63% in PC2. PC1 captures the change of the neck and rim and PC2 mainly captures the change of legs(Figure 34).

The results showed a dramatic change in PC2 from mid to late period, representing the leg of the Li becoming very bulging in the late period. However, the degree of change was greater than it in the middle period. There was no tendency to standardize obviously(Figure 34). In addition, although the CV of rim decreases significantly from the Middle to the Late Period, it is still at a high level of variation compared to other pottery types (Table 19).





Square: middle period; Round: late period

Figure 34 The result of EFA and PCA on morphological attributes of Li (1) the shape variation implied by EFA ; (2) the PCA results of EFA

To sum up, the above types of pottery except Li all found in both elite burial and the residential area. Therefore, they can represent both common and elite context. In the EFA results, pottery of different functions all shows the same characteristics as follows: firstly, there is a certain degree of overlap between the elite and the commoner context, representing that the two contexts share a number of pottery with similar shape; secondly, pottery in burial context all shows a greater diversity in shape compared to the ones from the commoner context, especially the samples from secondary elite burials; and in addition, in the examination of sizes, the pottery in top burials all shows

the lowest CV values, while the other two groups all show varying degrees of high variation.

Table 19 The CV result of cooking Li in Taosi site

Tripods Li	STDEV.	Average	CV
Middle	8.69	20.85	41.68
Late	4.26	19.33	22.03

There are also differences in the standardization and differentiation of these pieces of pottery. In terms of the degree of variation, both Jia and jars clearly show great diversity in the burials, especially in the secondary burials, while, on the contrary, Dou does not show great diversity in the burials. Secondly, in terms of size variation, the degree of variation of Dou is less than that of Jars and Jia, suggesting that the importance attached to serving ware has influenced the standardization tendency of the pottery.

As for the type Li, as a purely everyday cooking vessel and brought in by outside immigrants, the level of standardization remained low compared to other types of pottery, although the trend toward standardization increased significantly from the Middle to the Late Period.

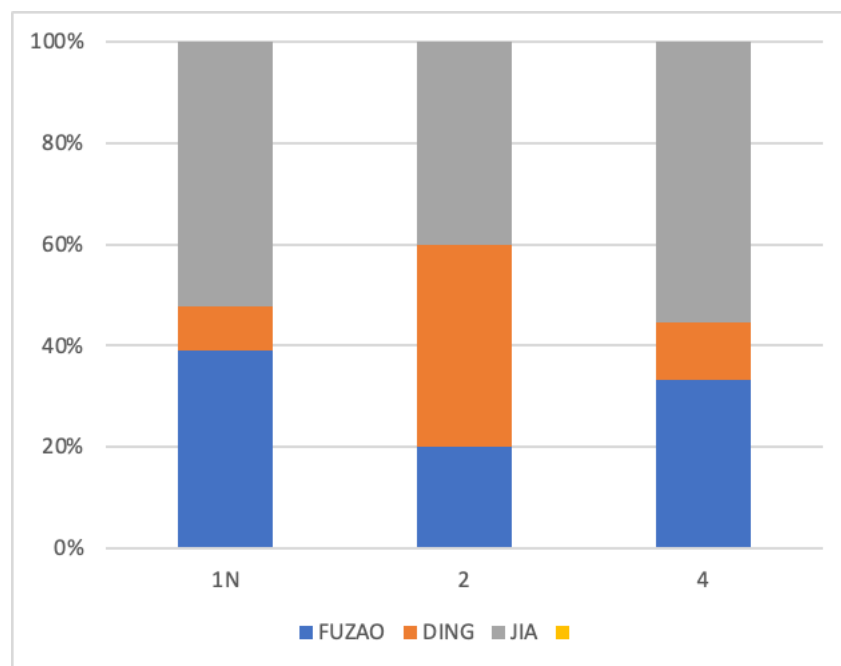
C. The consumption and distribution of pottery

The distribution of pottery in different contexts and areas can provide an effective understanding of the consumption of pottery and the exchange behavior of pottery in different social classes. Therefore, this part plans to examine the consumption and exchange of pottery in different consumption contexts. According to the previous analysis, we can know that the consumption scene of pottery in Taos can be divided into three categories.

The first consumption scene is the daily consumption of the elite group. This type is mainly represented by the pottery excavated from the palace area found in the middle period of Taosi, and the composition of the main ware categories is cooking vessels: Jia, Zao, types of jars, dou, etc., but due to the limited data found so far and the fact that

most of the excavated pottery is in fragments, a more detailed analysis is not possible.

The second scenario is that of the commoner. The research counted the pottery types excavated from the northern part of area 1 and area 4 (Figure 35). The results show that there is no significant difference in pottery types in each area, and all of them are ordinary pottery for daily use. Furthermore, there is no special complex decoration, such as painting. All the pottery found shares a strong practical function, proving that no special pottery consumption existed among these residential regions and that the pottery found was basically intended to meet the needs of daily life.



1N: District 1 North; 2: District 2; 4: District 4

Figure 35 The consumption of cooking vessels in the early period

Unlike the daily consumption scenario, the consumption and distribution of pottery in the burials were clearly influenced by political power and social organizational differentiation. According to the statistics on the different functions of pottery in the burials, Taosi burials do not rely on a single type of pottery but are more concerned with the combination of a whole cuisine set (Table 20; Figure 36). The higher the rank of the burial, the more evenly distributed the pottery combination.

Table 20 The number of different functional pottery in the burials

Rank	cooking	serving	storage	liquid storage	drinking
I	19	27	31	14	6
II-1	13	13	16	6	4
II-2	44	22	37	15	19
III	0	0	3	0	0
IV	0	0	5	9	0

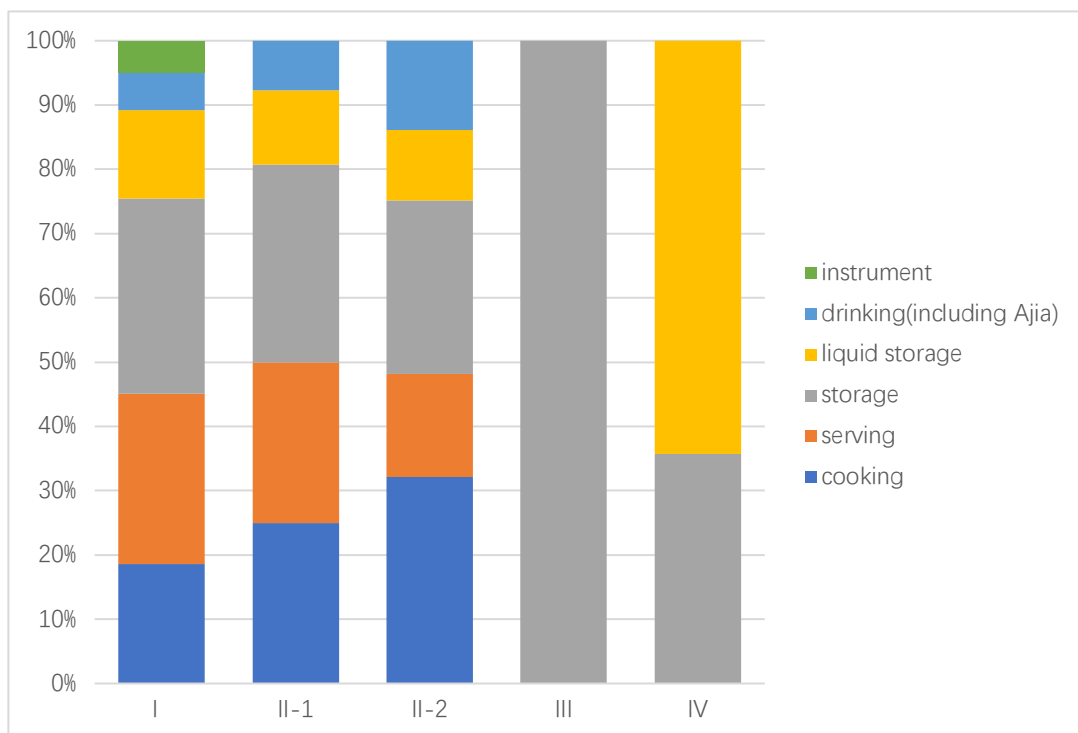
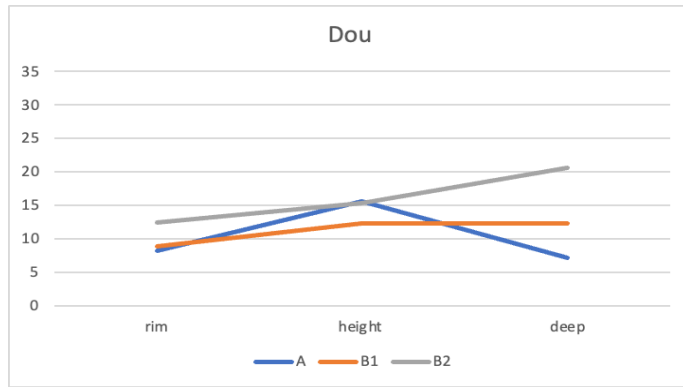


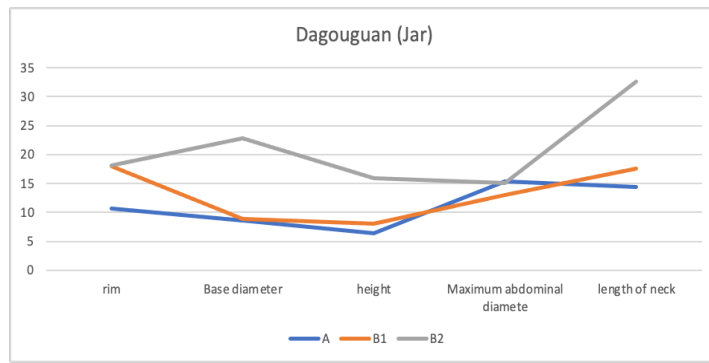
Figure 36 The component of different function of pottery in different ranks of burials

In terms of size, combined with the previous shape analysis(Figure 37), it is found that the CV of the highest-ranking burials(rank I burials) is smaller than that of rank II-1 and II-2 burials the burials in serving and storage vessels (Dou, Basin, and Jar). But the cooking Jia in burials shows a different situation, with a larger CV in the top burials.Furthermore, among the results, the Dou shows the highest degree of standardization, which is less than 10% in rank I and II-1 burials, while the jars and pen (basin) are below 20% and the cooking Jia shows the highest variation. Such variations indicate that different functional pottery performed differently in the burials. This may

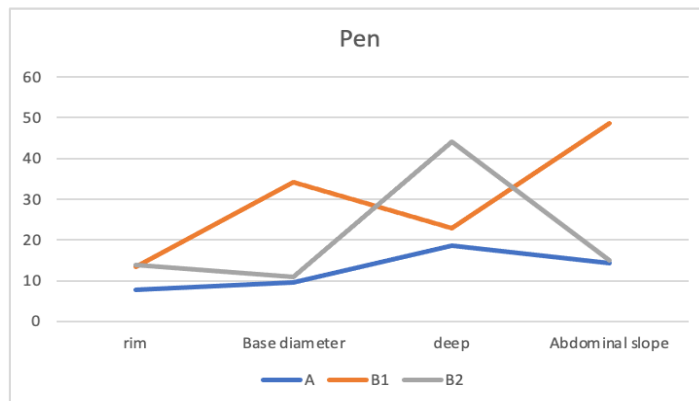
be the result of the intentional choice of elite intervention. The categories of vessels related to feasting were given more importance and received more control from the elite, resultin in the the relative less variation. Furthermore, the elite's intervention also contributes to the most standardized tendency in the top burials in feasting-related vessels.



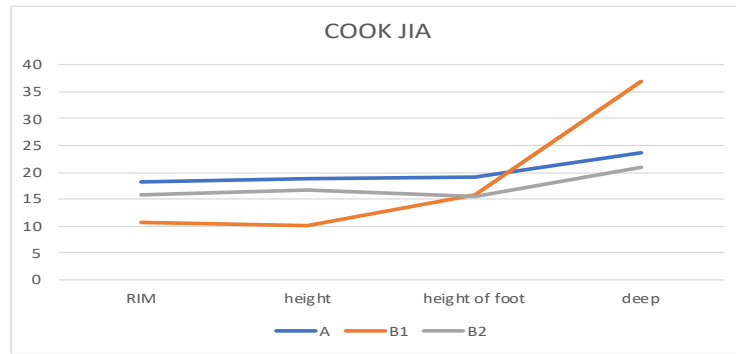
(1)



(2)



(3)



(4)

A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials

Figure 37 The CV result of different pottery in the burials

Taosi society's preference for feasting-related pottery reflects the importance they placed on feasting activities. Feasting is critical for the rulers to strengthen their power and negotiate with neighbors. Serving dishes are significant objects for the Taosi privileged because they allow them to demonstrate their identity during feasting festivities. And the elite's control of feasting pottery in ritual activities demonstrates their privilege over rituals and ancestor worship, demonstrating their ideological dominance as well.

The above three different scenarios of consumption illustrate two mechanisms of pottery consumption present at the Taosi site, especially in the early society. The first is for ordinary consumption, which is market-oriented and driven by the lives of ordinary household members, and the second is for elite consumption. Such consumption in the mortuary context is in order to demonstrate social status, clearly representing the political power of the elite as well as the superior role of the elite in ideological orientation.

However, for both types of consumption, the range of pottery exchange is limited to the site context according to the available evidence. First of all, from the clay data mentioned above, basically the raw material of both ordinary and the burial pottery belong to Class A clay, and similar chemical composition has been found in the local soil samples. Therefore, it is highly likely that the clay of the pottery was obtained nearby. The discovery of a large number of pottery kilns at the settlement site proves

that places where utilitarian pottery is consumed is the place where it is produced. This would suggest that ordinary pottery was exchanged through small daily exchanges, probably in an ordinary daily trading pattern. Such an exchange does not require a special market, is very easy to access and the scale is relatively small.

As for the burial pottery, because there are differences in the composition of the clay between the burial pottery and utilitarian pottery, some of the pottery may have been produced and consumed exclusively for mortuary practice. Such pottery ' water absorption is high and firing temperatures are lower than the utilitarian one. Based on the shape analysis, there is a degree of overlap between the burial and utilitarian pottery, which means they share the certain same shape (Figure 28, 30, 32). Furthermore, there are no significant differences in production techniques, except for the differences in clay ingredients and firing temperatures. This suggests that the potters who produced these burial pottery may have come from the production units located in the residential area. Moreover, there is no clear information that a specialized workshop has been found to produce such burial pottery, especially in the early period when the mortuary practice required a certain amount of burial pottery. Therefore, the potters living in the residential area had been hired or ordered by the elite to produce burial pottery exclusively, so this exchange relationship could be unequal. However, judging from the quality of the pottery and the small difference in shape and raw materials from those of the ordinary pottery, the control of the elite over such pottery probably was not exclusively strict. The elite was more intervened at the consumption stage by controlling the certain pottery access to the ritual scenes with less actual control over the production activities. So this exchange relationship was not strictly controlled and attached to the elite, but probably a form of ordering or tribute pattern when needed.

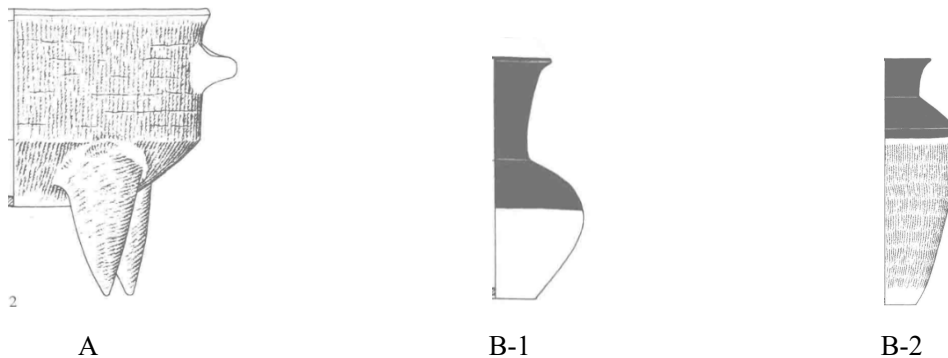
In conclusion, the exchange of pottery in early Taosi society was limited to the interior of the site. There is a clear division in consumption into two scenarios: elite burial use and everyday use. Although the elite had a special need for painted pottery, it was also obtained through household production units. They may have intervened in the pottery production through unequal means, but this control was very limited.

4.3.3 Color-painted pottery in mortuary practice

In previous burial studies, it was learned that the Taosi elite possessed a special burial ritual and tended to have sets of feasting pottery, especially color-painted pottery, in the high-rank burials, which were considered to represent the status of the elite. As a result, in this section, the color-painted pottery excavated from the Taosi cemetery is specifically examined to further examine the intervention of political factors on the consumption and production of pottery.

First, a simple classification of the decoration pattern on the pottery needs to be studied. According to the complexity of the decoration, it could be divided into four categories(Figure 38). The A type is no decoration or simple decoration without color painting, generally a cord or basket pattern, etc. The B category is a pattern that has a large area of red color painting. According to different combinations, type B can be divided into two subtypes: one is simply a large area painted red with no other decoration elsewhere, and the other is red painting with other simple decorations. The type C is the composite color painting, which is a combination of dots and red painting. Type D is the pattern with complex pictures.

The distribution ratio of these three categories of painted patterns in different rank of burials also varies slightly. The bar chart shows the distribution of different types of painting in different ranks of burials(Figure 37). The most complex pattern type D is mainly found in the top burial and B-2 class, while the slightly higher B-1 class is dominated by the B1 pattern. However, there is no case that a type of painting belongs to a specific class of burials. The distribution is generally even.



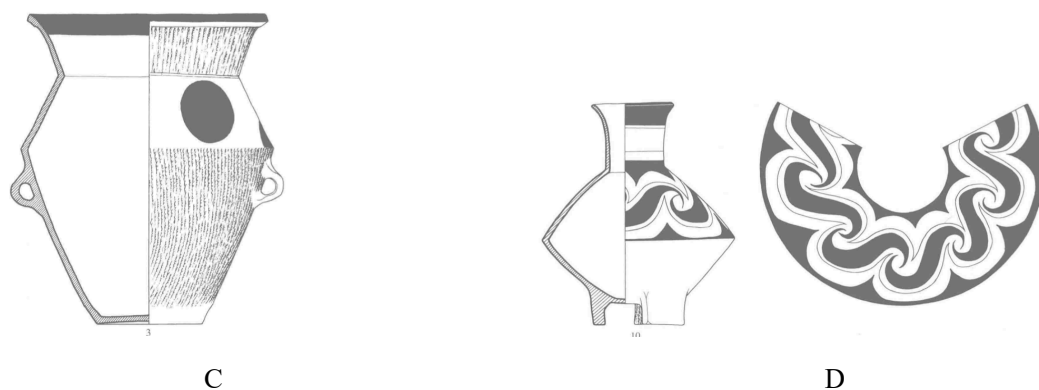
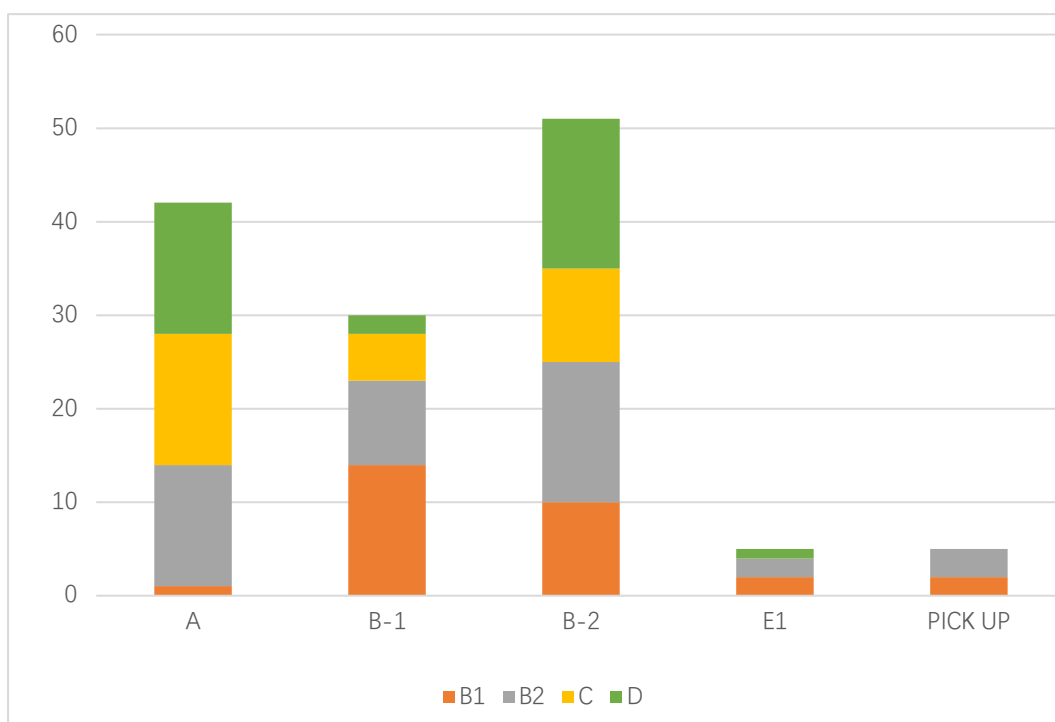


Figure 38 The decoration on the pottery in Taosi site



A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials; C: rank III burials; D: rank IV burials

Figure 39 The distribution of different types of painting in burials

In terms of the various types of painted pottery, the results show that the painting is most commonly found on serving vessels (Dou and Pan), liquid storage vessels (Hu and Ping), and storage vessels (various Jars and Pen) (Tabel 21). There are also different tendencies in the paintingson different types of pottery. The jars with long necks and jars with a folded- belly are dominated by they type B pattern, while type C is found mainly in jars with ah large orifice, and type D is found mainly in liquid storage vessels related to drinking behavior and, Pan, Pen, and Dou related to feasting activities. Based

on this distribution, it is possible that potters selectively applied the paint according to the different functions and social significance of the pottery.

Table 21 The number of color painted pottery in different context

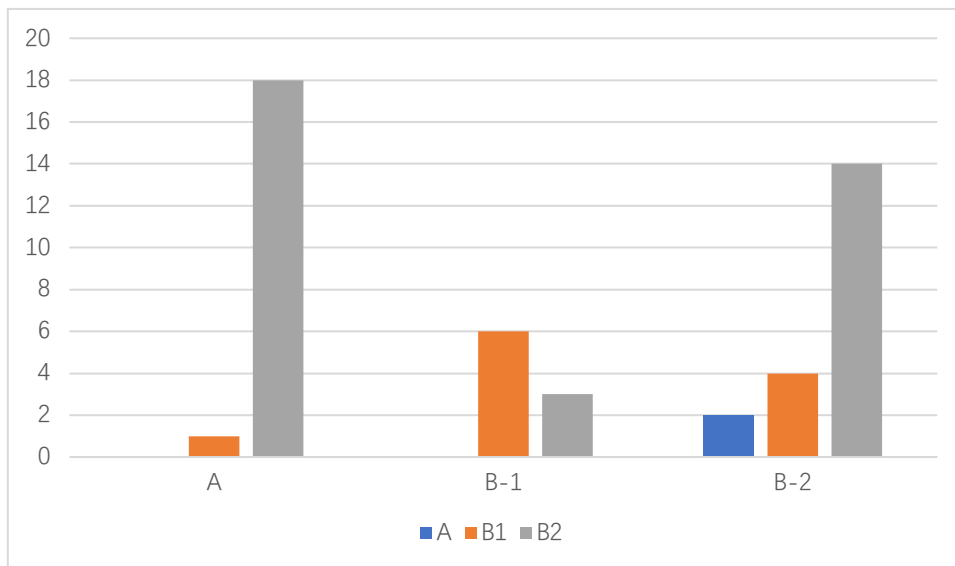
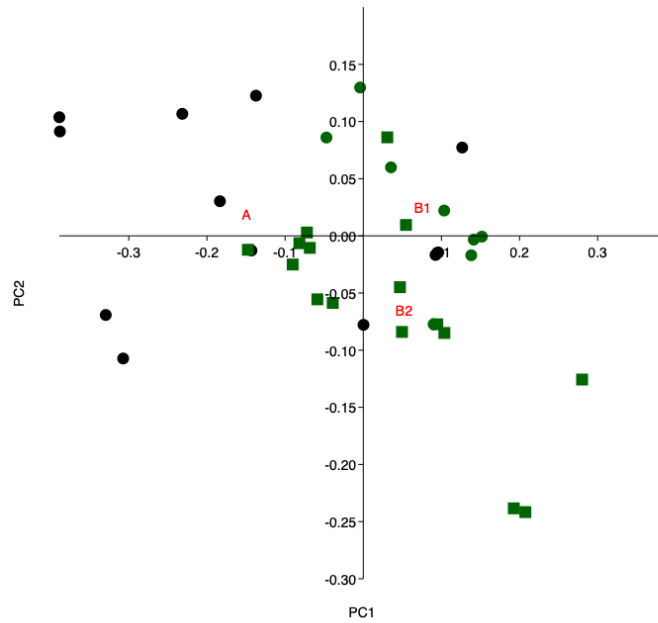
	total	context		The decoration type					
		burial	living	none	A	B1	B2	C	D
Jars with long neck	15	7	8	0	1	0	6	0	0
Hu	21	18	3	3	0	3	0	0	12
Ping	20	19	1	1	4	2	10	1	2
Jars with large orifice	44	31	13	0	6	0	2	25	0
Jars with folded belly	10	10	0	0	0	10	0	0	0
Pan	24	13	11	1	1	0	6	0	4
pen	23	13	10	0	1	1	0	0	11
Dou	50	32	18	0	3	9	17	0	3

A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials; C: rank III burials; D: rank IV burials

On this basis, the study further explores the behavior of the buried painted pottery by selecting several typical types of vessels that contain representative paintings.

Serving dou

The Dou mainly contains B-type painting patterns. Combined with the previous study on the shape geometry (Figure 40), the results indicate that the two types of patterns, B1 and B2, do not differ significantly in shape and overlap with some of the undecorated Dou. Among the different ranks of burials, the top burial is mainly dominated by type B2, and the secondary burial has both. However, the number of painted Dou in the top burials is higher than that in the secondary burials, and there is also a difference in quantity between the secondary burials; the number in the B-1 rank is almost double that in the B-2 rank. As a result, the average number of painted dou may correspond to social status in mortuary practice. The number in the higher ranked burials is larger as shown in the Table 22.



A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials

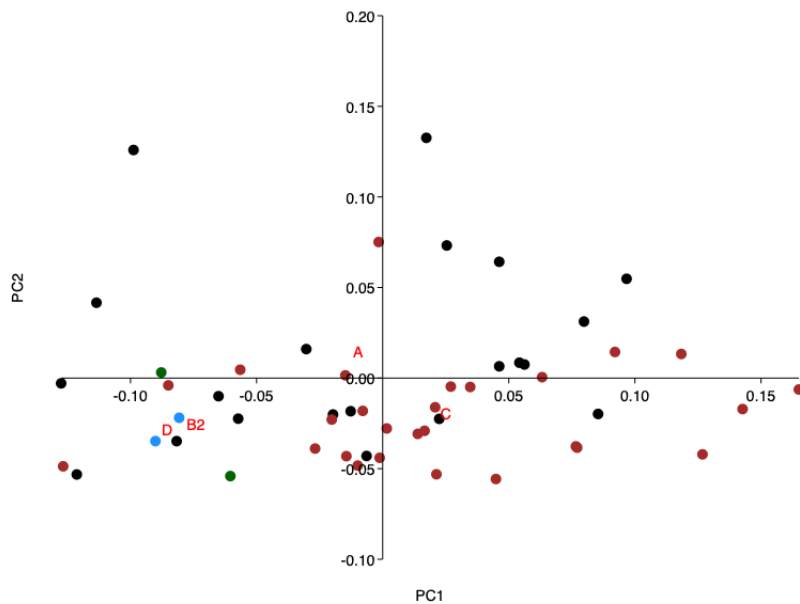
Figure 40 The distribution of decoration patterns in Dou (1) the morphological distribution; (2) the burial rank distribution

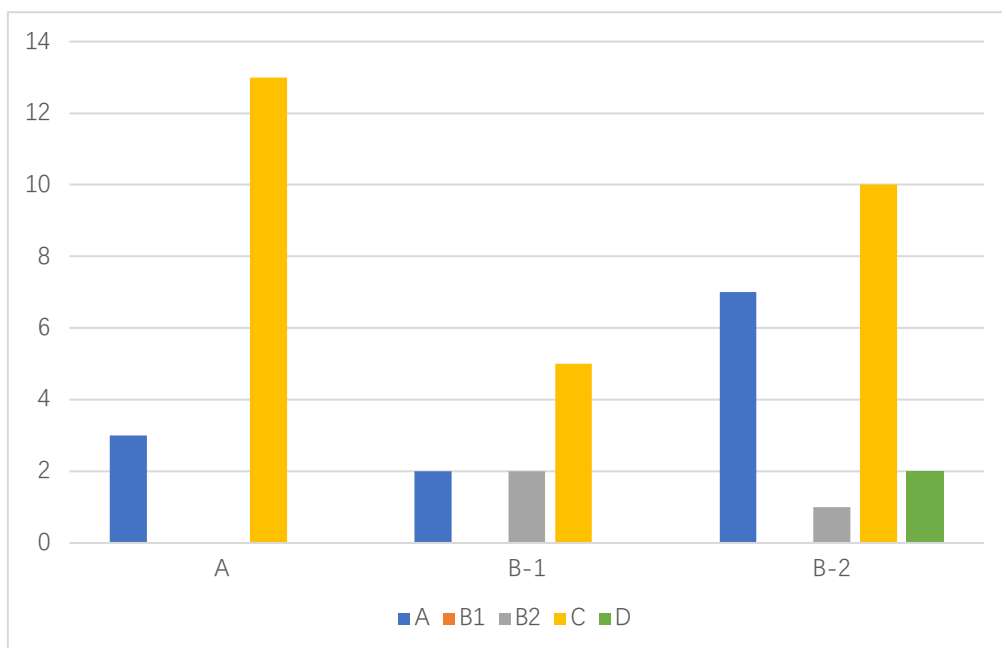
Table 22 The number of painted Dou

	B1	B2	total	number of burials	average
A	1	18	19	6	3.17
B-1	6	3	9	3	3.00
B-2	4	14	20	13	1.54
total	11	35	48	22	2.18

Jars with large orifice

The main painted pattern of jars with a large orifice is type C; simple decorations with red painting also occupy a part, a small portion, of the elaborately painted type D. Figure 38 shows the painting patterns in the morphological dimension. The samples with different patterns of decoration overlap with each other, and the results of the Manova test of the relationship between shape and types of decoration show that there is no difference in shape between the different decorated jars. Such findings indicate that there is no difference in shape with or without decoration, or even between different patterns of decoration. That is to say, there are no special shapes produced specifically for color-painted pottery.





A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials; C: rank III burials;
D: rank IV burials

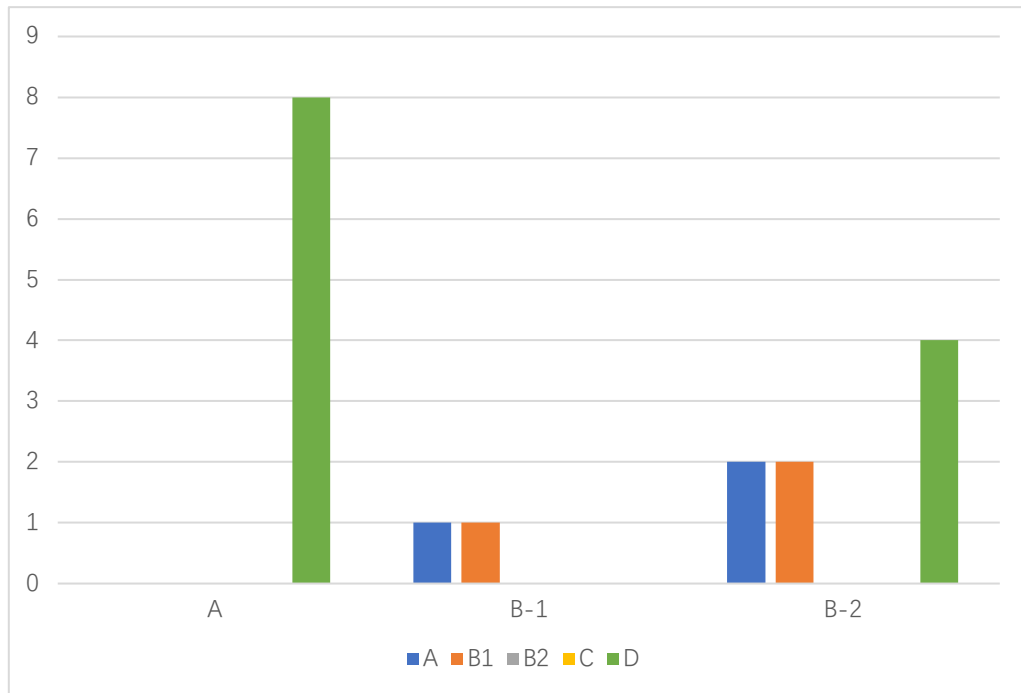
Figure 41 The distribution of decoration patterns in Jars (1) the morphological distribution; (2) the burial rank distribution

In terms of the distribution in burials of different types of paintings (Table 23), the most complex type D is only found in the secondary elite burials: type B-2, which shows that complex painting was not only enjoyed by the top elite. The only type of painting found in the top burials is category C, while multiple types of painting patterns were found in B-1 and B-2 burials. Furthermore, the average number of jars in a single burial in rank B-1 is the largest, followed by the top rank A.

Table 23 The number of painted Jars

	B1	B2	C	D	total	number of burials	average
A			13		13	6	2.17
B-1		2	5		7	3	2.33
B-2		1	10	2	13	13	1
total	0	3	28	2	33	22	1.5

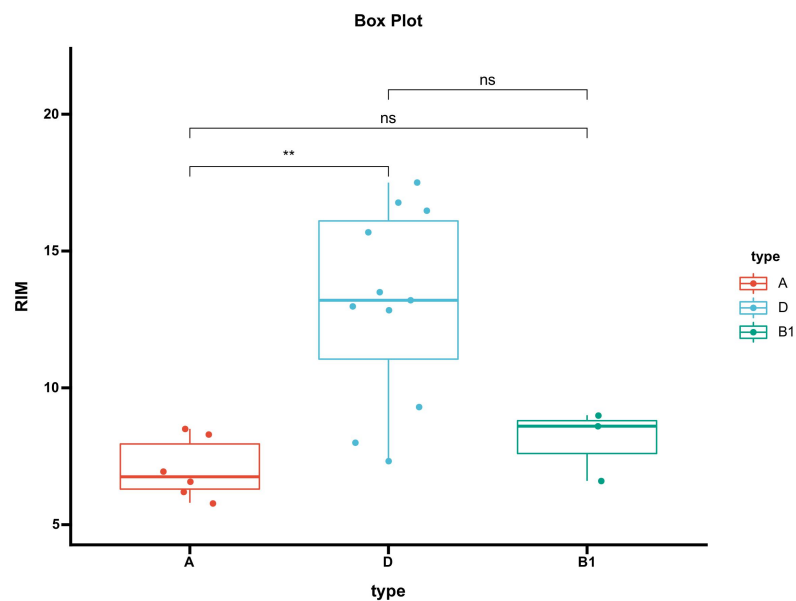
Hu($\frac{1}{512}$)



A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials; C: rank III burials;
D: rank IV burials

Figure 42 The distribution of decoration patterns in Hu

The hu has shown the special consumption tendency in the top rank burials. The top burials only contain D pattern painting while the B-1 and B-2 burials contain both B and D types painting (Figure 42).



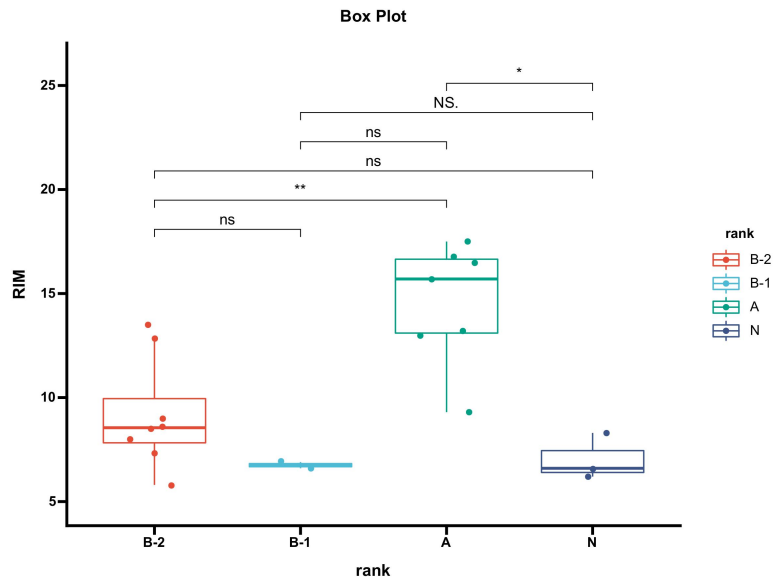


Figure 43 The rim of different decoration patterns of Hu and Hu in different ranked burials

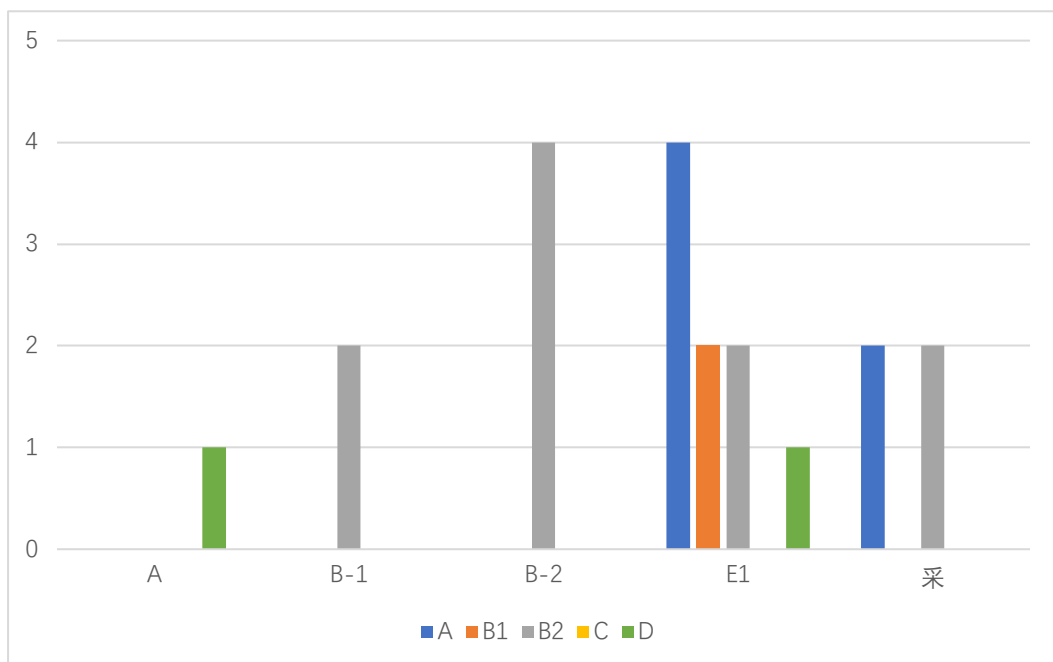
Due to the small number of complete vessels in the pots themselves, geometric analysis was not possible for Hu. However, the examination of the size of the rim revealed that the size of the painted Hu with type D painting is significantly larger than that with type B painting, but the range of variation is greater than that of type B (Figure 40). Furthermore, the examination of Hu excavated from different ranks of burials reveals that the size of the burials varies. The size of the top-rank burial is larger than that of the secondary burial. It indicates that the top burial tends to have larger pots and more complex decoration. Such behavior indicates that the top elites may intend to differentiate themselves from the secondary elite group. However, such a distinction was not the exclusive domain of the upper crust. The D also appears in the B-2 burials. The number of painted pots buried in single burials decreases from A burials to B burials (Table 24).

Table 24 The number of painted Hu

	B1	B2	C	D	total	number of burials	average
A				8	8	6	1.33
B-1	1				1	3	0.33
B-2	2			4	6	13	0.46
total	3	0	0	12	15	22	0.68

Ping (瓶)

The ping is different from other types of pottery, which are concentrated in elite burials. Ping has some special social significance and has been discovered in some special accompanying burials. These burials belong to type E1 in the classification, which has a large area and only has one piece of ping or one piece of ping with one piece of jade. These burials are always located next to the top burials, and the owners are female. Therefore, this type of burial could serve as a companion for the top elite (Figure 44;45).



A: rank I burials ; B1: rank II-1 burials; B2: rank II-2 burials; E: rank V burials;
采: collected

Similar to the Hu, because of the small number of complete samples, the size of the rim can only be investigated. However, the results differ from those of the Hu in that the Ping do not show significant differences in size tendencies among the different painted types and burial ranks. In terms of painted types, type D exists in the accompanying tombs. Class B tombs have only class B decoration, which is relatively simple compared with type D (Table 25). And the number of single burials does not correspond to the burial rank. The average number in the B-1 rank is the largest, and the least is the number of top tombs (Figure 45). It demonstrates that, despite the bottle's

special funeral meaning of accompanying, there is no discernible difference between the various levels of burial and the painting patterns.

Figure 44 The distribution of decoration patterns in Ping

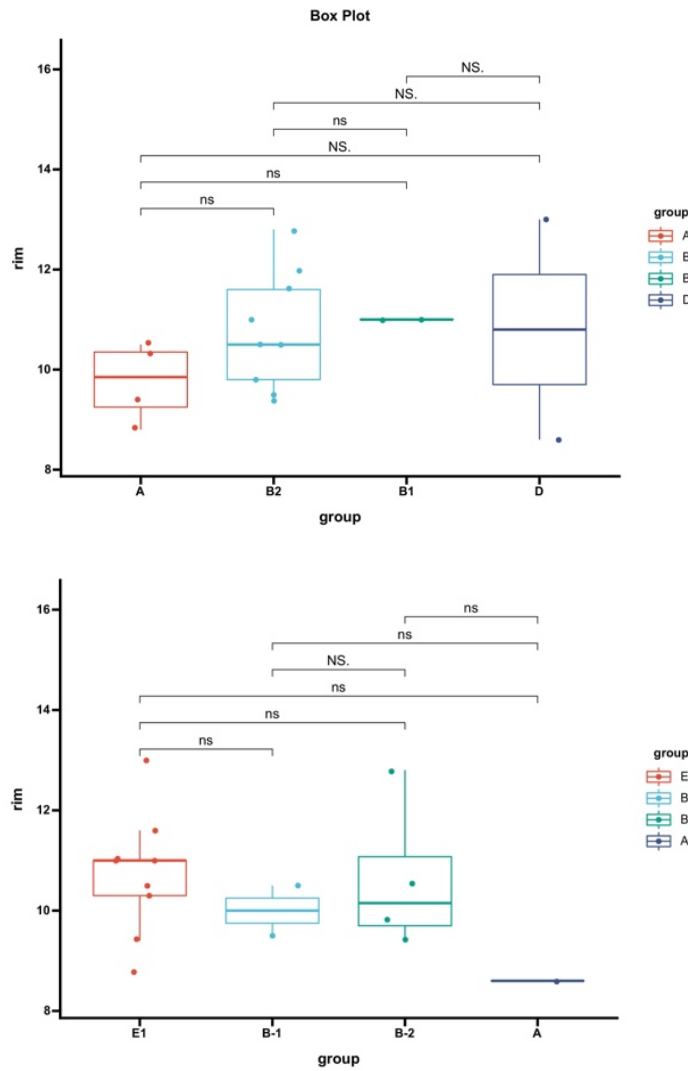


Figure 45 The rim of different decoration patterns of Ping and Ping in different ranked burials

Table 25 The number of Ping

	B1	B2	C	D	total	number of burials	average
A				1	1	6	0.17
B-1		2			2	3	0.67
B-2		4			4	13	0.31
E1	2	2		1	5	10	0.2
采		2			2		
total	2	10	0	2	6		

In summary, based on the above examination of the relationship between the shape

of representative painted pottery and the type of painting patterns, as well as the distribution in different ranks of burials, we know that the painted pottery not only represents the social status of the elite and the symbol of ritual meaning, but also the special type of pottery (Ping) that appears in the accompanying burial, which represents special status. Furthermore, painted pottery was primarily concentrated in the burials of the top two elite as a status symbol. There is no trace that these painted pots were used before being buried in the burials, indicating the color-painted pottery was produced specifically for the mortuary context. In Neolithic China, the red painting pattern and certain pictures could symbolize a certain meaning in the spiritual world and aspirations. The monopoly of the elite over the painted pottery in the burials may also indicate that the elite had a corresponding monopoly and leadership in the burial rituals and spiritual world.

Among the different types of painted pottery, the serving vessels (Dou and Hu) usually have the largest average number of top-rank burials, but the jars and Ping do not have such a situation. This shows that it is not the case that the higher the rank, the larger the number of painted pots. The responding situation exists only in a few pottery functions. Furthermore, the painted patterns do not strictly correspond to the differentiation of the ranks, and they can be found in all elite burials, but the top burials are biased towards only one type of painting, e.g., jars with a large orifice containing only Class C decoration.

Finally, by examining the relationship between shape and type of painting, it becomes clear that there is no specific shape that corresponds to a specific type of painting and that there is no special relationship between the two. Such a situation suggests that the pottery with and without painting was produced together, then attached separately. As a result, the color-painted production activities are not separated and specialized from the other pottery activities.

4.3.4 The pottery production system and specialization in Taosi society

The pottery production system in Taoist society was relatively simple. First,

pottery producers are not found to have a special social identity in Taosi society. They usually lived in a general living area and worked in the vicinity of their households while undertaking other activities, so they were not specialized professional potters in a strict sense, but the situation is more like that of ordinary people with high pottery-making skills who did not engage in pottery-making activities full-time but only used pottery as a means of supplementing their livelihoods. Such a household economic model with multi-craft production activities is very common in South America as well (Hirth, 2009). It is a proactive choice for families to avoid economic risks or improve their living conditions (Costin, 1991). These potters also received employment from the elite to produce burial pottery when needed, but they did not have a specific social identity.

Secondly, in means of production, whether it is utilitarian ware or burial ware or even painted pottery, their raw materials all come from the local area, and there is no raw material difference (Figure 24). There is no scarcity of raw materials, and they are easily available from the surrounding areas (Wang and Wang, 2013). Technically, the pottery of Taosi was made with a relatively high level of technology, using a combination of techniques such as coiling and modeling (Li, 2017). In addition, painting techniques were implemented on the surface of special pottery. This is an improvement over the previous Miaodigou II culture (Li, 2017). However, in terms of production intensity, as mentioned above, special production areas and a large number of production equipment or debris were not found, especially in the early period, indicating that the scale and intensity of production were not large. Also, the low level of standardization of the products themselves is not consistent with the large-scale, high-intensity production hypothesis (Stark, 1991). In terms of the organization of production, the kilns and working areas found so far were all located in residential areas (early period), sharing space with other living remains, and there was no large area dedicated to various pottery production processes. Therefore, pottery production would have been completed within the household space, so presumably the artisans would have consisted of members within the household or within the nearby community (Hirth, 2009).

The products themselves, such as pottery, also reflect the relative simplicity of the pottery production system. First of all, the Taosi pottery is divided into utilitarian and funerary wares according to the occasion on which it was used, where the funerary wares are mainly found in the elite burials and the burial pottery characterized by food and drinking vessel combinations represents the elite status and ritual rights. In terms of shape and size variation, there is no obvious trend toward standardization in the Taosi pottery examined; rather, the pottery in the burial context shows a greater diversity in shape compared to the pottery in the residential area, especially the one from the secondary rank burials, which shows a clear diversity. In the intergroup examination, there is no difference in shape between the burial pottery and the ordinary pottery (Table 14), suggesting that the burial pottery was not specifically produced and that it was probably produced in the general residential site along with the utilitarian pottery. Although there are no obvious differences in shape, the different functions of pottery vary somewhat in the standardization examination. Both cooking and storage vessels clearly show great diversity in the burials, especially in secondary burials, while serving vessels do not show great diversity in the burials, and the degree of variation is not particularly evident from the settlement site. Secondly, in terms of size variation coefficient, the overall degree of variation of Dou is smaller than that of jars and Jia, indicating that there is a certain difference between pottery vessels of different functions. As serving vessels, Dou were closely related to feasting activities, so the Taosi elite, who attached importance to ritual and feasting activities, may have consciously intervened in the production of Dou, requiring them to be more standardized than other types of pottery for use in feasting and ritual activities, thus symbolizing their status (Liu, 1999; Underhill, 2002). In general, therefore, although there was no clear specialization in the production of a particular type or function of pottery, the differences in standardization suggest different production strategies for different types of pottery due to social symbolism and the involvement of the elite.

In terms of exchange and distribution pattern, the exchange of pottery from Taosi was most likely restricted to the site itself, both in terms of social and geographical distance. There is no evidence that the Taosi pottery originated from other sites, and the

presence of pottery-making units within the Taosi site, with shapes and clays similar to those found in the settlement, makes it likely that the pottery found in the Taosi site was locally produced. It is noteworthy that in early Taosi society, funerary behavior required the provision of a certain amount of burial pottery, especially colored pottery, which probably also came from the pottery-making units at the settlement site. The ordinary potters at the settlement site may have been hired or ordered by the elite to specialize in the production of burial pottery, so this acquisition relationship may have been unequal. Two patterns of pottery consumption are visible among the consumption components in early Taosi society. One is the ordinary consumption of the market-oriented household livelihood as the starting point of ordinary consumption to meet the general needs of ordinary people. There is no special difference. The other is the elite intervention pattern. Such consumption is meant to demonstrate social status, obviously representing the elite class as well as an ideological orientation.

According to the above explanation of the component of the Taosi pottery production system(Figure 46), it can be seen that two different mechanisms existed for the pottery production at Taosi: the first pattern involves a certain degree of elite intervention, primarily manifested on the production and consumption of burial pottery, particularly painted pottery, by consciously imposing painted or rich pottery combinations, but the degree of such intervention by the elite class varies. The producers of these precious potteries belonged to the same group of potters as the general potteries, and these producers did not leave their original backgrounds nor did they have special identities. Moreover, they did not consciously use scarce materials and different techniques. Although there are clear hierarchical and distributional differences in the burials, the quality, shape, and raw material of the pottery do not differ much, suggesting that the control of the elite over this type of pottery probably only existed in the consumption phase with less actual control over production. Through the meaning of feasting and painting on the surface, the precious pottery is most likely associated with a ritual meaning in the funerary phase. This type of semi-employed, specialized production can also be found in other societies around the world. For example, in Hawaiian chiefdoms, the chiefs occasionally commissioned canoe

manufacturers and possibly other woodworkers. Adze manufacturers were likely independent experts who occasionally supplied equipment to canoe makers and other people working on major undertakings (Lass, 2008). So this exchange relationship, although it received the influence of the nobility, was not one of strict control and attachment but perhaps an exchange in the form of subscriptions or tributes when needed (Blackman et al., 1993). The second pattern is the production system for ordinary utilitarian pottery. It is obtained through general exchange or trade over short internal distances, and there are no specific regional differences. Its function is only to satisfy daily consumption.

Although there are differences in the production motives, consumption contexts, and forms of exchange between the two patterns, there is no institutional or material separation of the production units. They exist together in a common context and are most likely to come from the same producers and production units. Different pottery was produced or further processed to meet the various consumption needs. From this point on, it can be seen that even the production of precious pottery under the intervention of the elite did not reach a high level of specialization without special attached potters, production space, and units. Thus, the level of pottery specialization in the production of pottery in Taoist society was based on household economics and driven by two mechanisms.

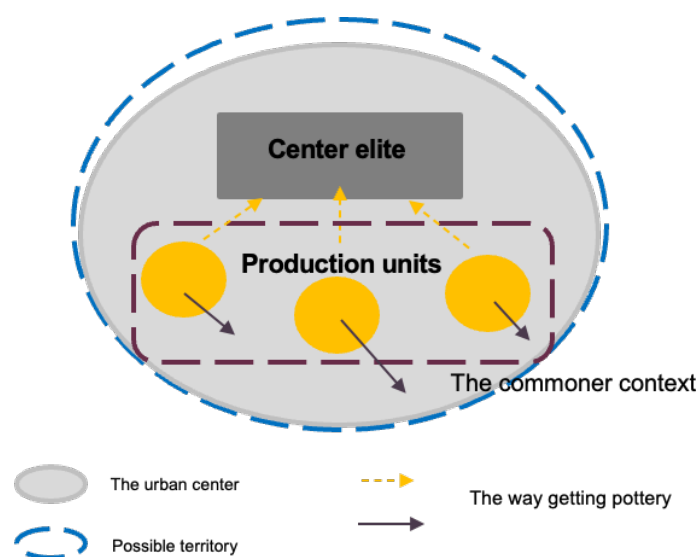


Figure 46 The pottery system of Taosi site

4.4 Summary

This section began with an analysis of the settlement arrangement and burial behavior at the Taosi site. This part investigated the complex social structure of Taoist society, including a high degree of social differentiation, a strong central authority, and a variety of production activities based on households. Then, this chapter continues to investigate the production system at the Taosi site, especially in the early period, based on direct and indirect evidence. In the early period, the production units were mainly found in the household context. Even though the middle and late periods witnessed the separation of production sites, implying an increased degree of specialization, pottery data is missing. Therefore, it is hard to investigate the production system and pottery specialization in the middle and late periods. The examination of pottery has shown a relatively low degree of specialization. The clay for pottery, whether used in elite burials or by the commoner, is all from the same area and has no discernible difference. The pottery varied greatly in shape and size, but differed in function and social significance. Such differences imply the possible intervention of elites in pottery production, but their power is limited.

Chapter 5 Pottery production system and specialization in Erlitou

Culture

5.1 Introduction

In this chapter, the study focuses on the pottery production system of the Erlitou culture and the possible level of production specialization. The Erlitou culture was widely distributed with settlements centered on the Erlitou site, and the Erlitou society is considered to be representative of the Chinese early state with a wide area of cultural influence. Therefore, in this section, the samples from outside the Erlitou site area are also included in the examination of social structure and prestige pottery while studying the pottery production system.

Previous studies have conducted studies about pottery in Erlitou culture from different perspectives. However, there is no detailed discussion of pottery production systems and the specific links to the early state process. Because the pottery workshops excavated so far are dispersed, they are usually regarded as having a dispersed organizational form, but other specific characteristics are not clear. Such a situation should be clarified. Therefore, this chapter plans to clarify the relationship between pottery production systems and overall social changes through a comprehensive examination of different attributes of pottery.

This chapter will be divided into five parts. The first part provides a comprehensive analysis on the social structure of Erlitou. This includes the chronological framework for the study, then the research discusses the pattern of urbanization processes at the Erlitou site, including a central urban of the Erlitou culture and surrounding area in the territory. Then, the mortuary practices throughout the Erlitou culture will be studied to reveal the multi-layered social structure of Erlitou society in a wide area. The purpose of this part of the study is to clarify the complex socio-political system at Erlitou, and the settlement patterns and different ranks of burial behavior provide the context for subsequent comparisons of pottery in different.

The second part examines the production remains found so far as well as the pottery products themselves. It includes an analysis of the relatively small number of production equipment and tools found so far. In this case, the role of pottery production units in the urban center is illustrated. In the study of the pottery products themselves, further analysis of changes in the raw materials of pottery in different temporal and spatial contexts is provided based on published data. In addition, as in the case of the Taosi site, this section selects different functional pottery vessels, including cooking vessels (deep-bellied jars, li), storage vessels (large-mouth Zun), and drinking vessels (Jue and He), to examine the degree of geometric and dimensional variation and compare the results in different spatial and temporal contexts to discuss whether these pottery vessels were significantly standardized or differentiated, and then to examine the socioeconomic and political motivations that influenced the existence of such results. Within such analysis, in response to the special social function of drinking vessels in Erlitou society, which had an important role in sustaining rule in a broad sense, samples of drinking vessels excavated from different sites in a wide area are included. Part three, building on Part two, further discusses the consumption and exchange of pottery in Erlitou society. Part four concentrates on the white drinking vessels found in Erlitou society. The special production system and distribution of white pottery are discussed through an examination of its consumption and distribution in different regions and periods.

5.2 The social system of Erlitou Culture

This part focuses on the analysis and discussion of the social system of Erlitou society, including the discussion of chronological framework, and settlement pattern both inside Erlitou site and outside the wide territory of Erlitou society. Such discussion could imply the basic economy and political system of the Erlitou society. Then, the research also applies quantitative methods to re-analyze the Erlitou burials in central site and local settlements respectively in an attempt to explain the social organization of Erlitou society. These three parts can be combined to illustrate the whole social

system of the Erlitou Culture comprehensively.

5.2.1 Chronological framework

The chronological framework of Erlitou culture is built on the typology of pottery. Although the four-phase division is the most commonly used in current research, there have been multiple phasing schemes from the discovery of the Erlitou culture to the present, so it is necessary in this part to examine different phasing schemes in a comprehensive manner. The two main phasing schemes that exist are the four-phase division and the five-phase division (Zhongguo, 1999; 2014; Peng, 2011; Qin, 2019). Among them, the four-phase is the most widely used, and the two official excavation reports released about the Erlitou site currently use such a staging scheme (Zhongguo, 1999; 2014). In addition, Qin's findings, which focus on separating the temporal and spatial variations of pottery from different systems, also endorse and apply the four-phase division and adopt a consistent temporal and spatial framework in the wider area of Erlitou culture (2019). The main difference between the five phases and the four phases is the division of the fifth phase, which, after a horizontal comparison, partially confuses the Erligang culture of the Erlitou site and includes some samples from the late fourth phase, so there is a vague definition of the Erligang and late Erlitou 4 phases in the five-phase scheme. The four-phase theory clearly distinguishes the two distinct cultural periods (Figure 47). Therefore, the four-phase one is more supported in this research. However, according to the latest research and reports, the late stage of phase 4 is important transformation period of Erlitou society, and also a transitional stage from Erlitou culture to Erligang culture. Zhao argues that this period may equals the lower Erligang layer of the site (Zhao, 2016; Li, 2018). Therefore, the late stage of phase 4 shared some characteristics Erlitou and Erligang Culture and is worthy of attention. Under such considerations, the research plans to divided the sample from phase 4 into the early stage ones and late stage ones according to the latest archaeological reports (Zhongguo, 2014) to investigate pottery production in this special period. Although the above two staging schemes disagree on the division of the last phase of the Erlitou

culture, the trend of pottery change is the same.

From the published dating, the latest C14 results are : the first phase at BC 1750–16800, the range of the second phase at1680–16100, the third phase at1610–15600, and the fourth phase at1560–1520 (Zhang et al., 2007).

	Jar with deep abdomen	Jar with round abdomen	Pen	Pen(鬲)	Dou	Basin
Phase 1 late						
Phase 2 early						
Phase 2 late						
Phase 3 early						
Phase 3 late						
Phase 4 early						
Phase 4 late						

Figure 47 The choronoly of Erlitou culture(partly, Zhongguo, 1999; 2014)

5.2.2 Settlement pattern of Erlitou site and settlement changes in periphery area of Erlitou culture

5.2.2.1 The Erlitou urban core: Erlitou site

The Erlitou site has been excavated for decades, and the basic form and function of the site have been clarified (Zhongguo, 2014; Zhao, 2020). The extent of the Erlitou site was determined during the 1999-2000 survey (Figure 48:1). The central area is considered to be the area of elite activities, valuable craft production, and burial rituals, while the general area for the most commoners in the northwest has not been excavated (Zhongguo, 2014). The general area in the northwest has not been excavated so far. Therefore, the published data are mainly focused on the central area and part of the commoner living area.

The first phase of the Erlitou site was in the budding stage of the Erlitou culture, but this period covered an area of more than 1 million square meters and was already the largest center in the Yiluo region (Figure 48:2). Some valuable craft products already existed in this period, and a large pit number one was found, presumably where soil was taken for the subsequent construction of the large rammed buildings. At this phase, the craft activity focused on the bronze items, bone tools, etc., and some agricultural, fishing, and hunting tools were also found on the site (Zhongguo, 2014). However, the clear layout of the settlement in this phase is not clear at present and may have been destroyed by later accumulations, leaving less complete evidence.

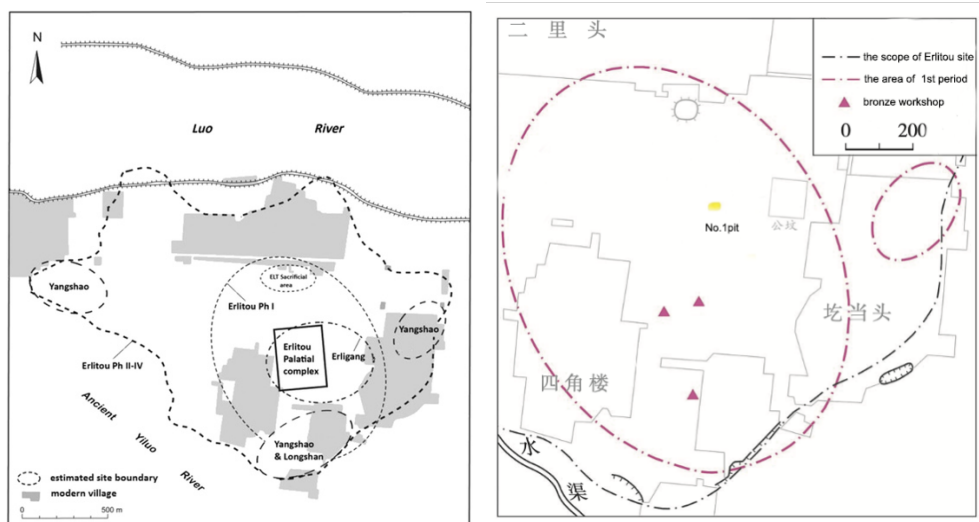
The second phase was a period of rapid development and social integration for the Erlitou culture (Figure 48:3). The initial urban center was formed at this time. The area covered during this phase reached 3 million square meters. The early stage of this phase began with building a well-shaped road network in the central area, after which the functional differentiation of the palace area, the ritual area, the workshop area, and the residential area had been formed in turn. Within the so-called palace district, the large rammed buildings No. 3 and No. 5 with their large area and complex layout were built, and in the interior of these buildings were many elite burials. Many prestige items, such

as bronze and turquoise plaques, and other high-value burial goods were found in these burials. Some high-ranking burials were also found in the northern and eastern parts of the palace area. The small area of walled workshops adjacent to the south of the palace area is a turquoise production workshop area, and to the south is a bronze workshop. Some small houses and burials were found close to these workshops, which may be the area where craftsmen and their families lived. In the east of the palace area, the No. 1 bone workshop was discovered during recent excavations. In addition, small bone production units and possible processing sites for stone tools and pottery were scattered throughout the settlement. This period also witnessed large-scale population migration, which served as the basis for the continued construction of the Erlitou settlement during this period, with further functional differentiation and the coexistence of various crafts.

The third phase of Erlitou was the period when the Erlitou culture reached its peak. Experts estimate that the population of Erlitou peaked at 18,000-30,000 people during this time period (Figure 48:4), and various craft production also grew rapidly at this time, as did mature urban layouts. At the turn of the second and third phases, walls were built around the periphery of the palace area to enclose it, creating a clear division with other areas and highlighting the core position of the palace area. In addition, the original 3.5 rammed earth buildings were abandoned, and new, more closed No. 1, 2 rammed earth buildings and relevant No. 7-9 buildings were built. Furthermore, the burials did not appear in the palace area. The two elite cemeteries were established outside the palace area. The original turquoise workshop and the bronze casting workshop continue to produce, among which the bronze casting technology has produced significant progress with a wider variety and quantity and the innovative use of sophisticated techniques to produce bronze vessels. In addition, Bone Workshop No. 1 continued to process stone and bone tools. The distribution of functional areas did not change dramatically, and the production of various crafts continued to flourish in the early section of the fourth phase. The No. 1 bone workshop may have been relocated. However, in the late stage (Figure 48: 5), the road network, the palace walls, and the No. 1 and No. 2 groups of political and ceremonial projects of the Erlitou capital appear to be destroyed, which is an unprecedented phenomenon; in particular, cultural

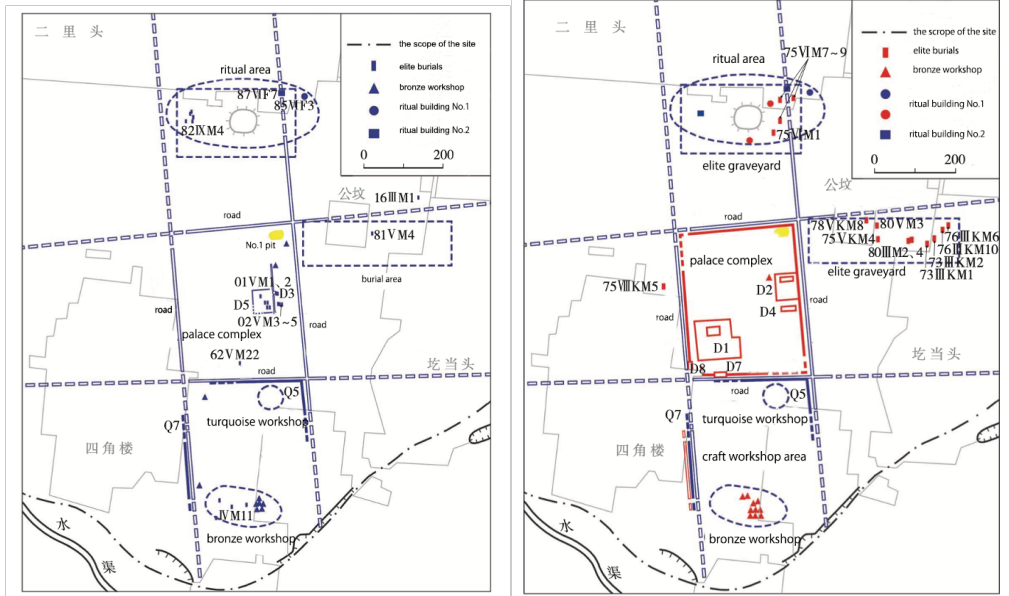
elements from the Xiaqiyuan and Yueshi cultures suddenly appear in the Erlitou site. The construction of the No. 10 rammed earth building in the eastern section destroyed the original layout of the Erlitou capital. Although the new building No. 6 was built, the overall scale was much smaller. The bronze and turquoise workshops continued to function. In the palace area, there was also a bronze production unit. Zhao(2016) summarizes by the breaking relationships of different archaeological units that the main political elements in the late phase 4 in Erlitou site were damaged to different degrees and that elite burials characteristic of Erligang culture were found in the central area. All of this evidence attests to the invasion of rival regimes at this time. Miyamoto (2019) argues from the perspective of the bronze manufacturing process that the Erlitou society at this time was casting prestige bronze vessels for the elite of the Erligang culture. The above indicates that the Erlitou site was still a high-ranking settlement, but its main users belonged to a different political group, maybe proto-Shang group.

After a period of use of the above-mentioned rammed earth buildings No. 6 and 10, the copper casting workshops and turquoise workshops were abandoned afterwards(Figure 48:6). After a short blank period, the Erlitou site was completely reduced to a general settlement in the late Erligang culture.



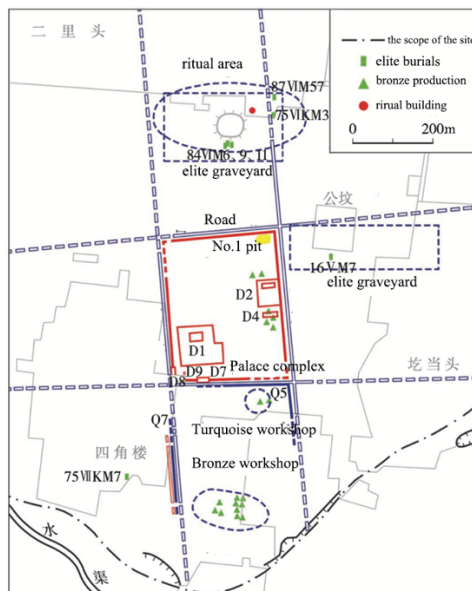
(1)

(2)

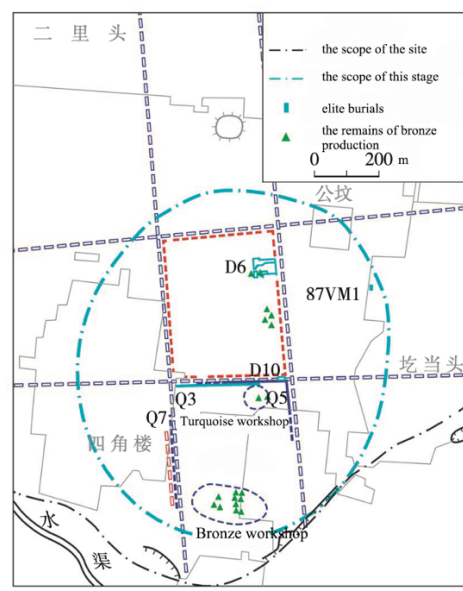


(3)

(4)



(5)



(6)

Figure 48 The settlement pattern of Erlitou site (1) the overall range (2) 1st phase (3) 2nd phase (4) 3rd phase (5) 4th phase (6) 4th phase late stage (based on Zhao, 2020)

The Erlitou site's development process, from its rise to its peak to its reduction to a small settlement, reflects the process and characteristics of the continuous urbanization of the center during the early Chinese state's development process (Xu, 2015). On the one hand, the continuous development of agricultural and craft production promoted the continuous development of urbanization under the premise of the continuous

concentration of population, which was driven from the bottom to the top. The demand for ritual objects also contributed to the importance of the attached craft production in the urbanization of Erlitou, reflecting the top-down impetus. In summary, the urbanization of the center was the result of a combination of factors during the early state's development.

5.2.2.2 The wide territory of Erlitou culture secondary regional center and the periphery

The Erlitou culture was widespread, encompassing almost the entire Central Plains of China, concentrated in the Yiluo Basin, the Zhengzhou Plain, parts of southern Shanxi (Jinnan, 2022), and the southern region of Henan(Figure 49). Some scholars believe that the influence of the Erlitou culture reached the middle reaches of the Yangtze River, as Erlitou cultural attributes have been found within some sites, and it is controversial whether Erlitou political control reached this area (Liu, 2005). However, it is undeniable that the Erlitou society had established a four-level settlement system over a wide area, centered on the Erlitou site and supported by sub-regions, and received deep influence from the Erlitou center.

The Yiluo region is considered to be the core area of the Erlitou culture distribution, and there are several sub-centers, including Nanzhai, Huizui, Shaochai, Nanwa, etc. The systematic survey and excavation projects in the core area of Erlitou have revealed that these centers may have different social functions. Shaochai is considered to be the sub-center of Erlitou society, with a larger scale and a common traditional social organization (Nishie and Kuji, 2009). It quickly became the center of the Yiluo Valley through the support of the Erlitou central regime in Phase I and is considered a center for the management of the Yiluo Valley's natural resources and exchanges with other regions. In addition, Huizui and Nanwa were centers of craft production. Among them, Huizui was a production base for lithic tools, and Nanwa was a production base for white pottery (Liu, 2005). Although previous studies suggest that the products produced at these two sites primarily served the Erlitou center, the

production and distribution of these products do not seem to have been strictly controlled by Erlitou, and there was some exchange between the regional centers, but further examination and research are needed(He, 2022). The numerous centers in the Yiluo Basin existed throughout the Erlitou culture period, demonstrating their close relationship with the Erlitou center.

The peripheral areas beyond the Yiluo Basin also existed as regional centers of their own and are thought to have received control due to different socio-political functions. Access to resources is considered one of the driving forces controlling these distant regional centers. The Jinnan region is rich in salt (Hedong Salt Lake in Yuncheng) and copper resources (the Zhongtiao Mountains); the regional expansion of the Erlitou culture was clearly driven by the acquisition and control of these two resources controlling these distant regional centers. The Jinnan region is rich in salt (Hedong Salt Lake in Yuncheng) and copper resources (the Zhongtiao Mountains); the regional expansion of the Erlitou culture was clearly driven by the acquisition and control of these two resources. The Dongxiafeng and Nanguan sites, on the other hand, were the larger centers of the region(Liu and Chen, 2012; Liu, 2005). With rich maritime remains, copper smelting activities are also found at these two sites. Evidence of the influence of the Erlitou regime is also found in the burials and sites at the Dongxiafeng site: drinking vessels symbolizing the Erlitou ritual system and everyday pottery in the Erlitou style, among others. This area may have assumed the function and responsibility of obtaining salt and copper and transporting the resources to the Erlitou Center. A regional center was formed to serve from the second phase of Erlitou. In addition, the middle reaches of the Yangtze River were also rich in copper and turquoise resources, and a large amount of pottery in the Erlitou style has been found in Panlongcheng.

Secondly, military needs led the Erlitou regime to establish important military strongholds in the northwest, south, and east. Representative of these sites are the Dashigu and Wangjinglou sites in the Zhengzhou area, which developed mainly in the third and fourth phases of the Erlitou culture. With a large area of trench settlements and the discovery of numerous relics of the force element, they are considered to be important military sites for the defense of the Yueshi culture in the east and the pre-

Shang communities in the north(Qin, 2019).

Thus, Erlitou society as a whole was involved in a complex political and economic system. Aggressive cultural expansion was motivated by military politics as well as control of resources. At least by the third period, such wide-area formal economic entities had been formed.

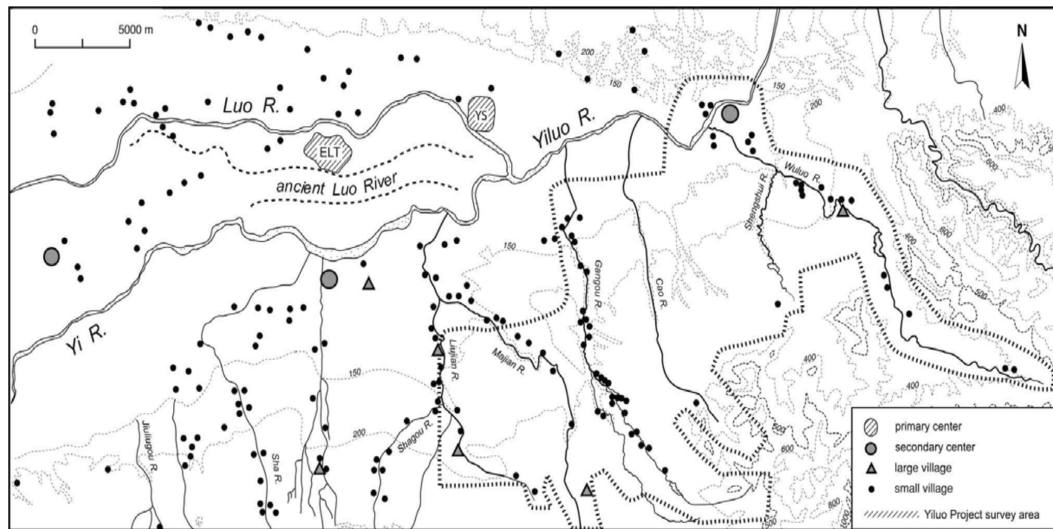


Figure 49 The map of possible influenced area by Erlitou culture(Liu and Chen, 2012)

5.2.3 Mortuary practice of Erlitou culture

From the 1950s to now, more than 500 burials have been found in the Erlitou culture: more than 400 burials in the Erlitou site and 180 burials outside (Zhongguo, 1999; 2014). However, the published data is fragmented.

Similar to the Taosi cemetery, previous attempts have been made to classify the burials of the Erlitou culture, especially the hierarchy, according to the principle of labor input, and based on these classifications, the basic social structure and the basic burial patterning in the Erlitou society have been explained. Li's (2005) master's thesis may be the most comprehensive classification of burials and argument of changes and ritual systems. His results have also been cited mostly in the following burial studies. His results have divided the burials into five different types, corresponding to four different ranks in the society. Besides that, the stratified society has been described, and the burial assemblages that correspond to the hierarchy after the third phase show a trend towards

ritualization and the possibility of distribution within the periphery. Similarly, Miyamoto (2005, 2007) focused on burials at the Erlitou site, and he argues that the five levels of burials in Erlitou society represent the five levels of social organization. And a clear system of social rituals has been formed, represented by a bronze and ceramic prestige system.

Although previous burial studies reveal the complex social outcomes of Erlitou, there is a need for further refinement of thinking on the relationship between central and regional groups. The previous classifications of the burials in Li's research (2005) put the burials from central and local areas together. Such classification is based on the premise that social structures and customs were consistent over a wide area, ignoring the possible individuality of each area and the possible existence of different social structures in different sub-regions. However, such an idea needs more support and evidence.

Table 26 The burial data in the wide Erlitou Culture

Site name	Area	count	Site name	area	count
Erlitou 二里头	center	207	Luodamiao 洛达庙	Zhengzhou	17
Dongmagou 东马沟	Yiluo	10	Wangjinglou 望京楼	Zhengzhou	15
Huizui 灰嘴	Yiluo	3	Dashigu 大师姑	Zhengzhou	6
Baiyuan 白元	Yiluo	5	Xishicun 西史村	Zhengzhou	5
Zaojiaoshu 皂角树	Yiluo	1	Dongxiafeng 东下冯	Jinnan	8
Nanzhai 南寨	Yiluo	25	Xiangdong 穰东	Xiangdong	1
Beizhai 北寨	Yiluo	1	Xiazhai 下寨	Southern	3
Zhengyao 郑窑	Yiluo	4	Shangpo 上坡	Southern	4
Shaochai 稍柴	Yiluo	7	Haojiatai 郝家台	Southern	29
Nanwa 南洼	Yiluo	11	Xiawanggang 下王岗	Xiawanggan	6
				g	
Wangchenggang 王城岗	Yiluo	7	Donggangou 东干沟	Donggango	8
				u	
Dongyangcun 东杨村	Yiluo	7			

In this part, the research plans to use multivariate analysis to analyze the burial behavior among different areas separately. To address these issues, the burials in different areas of Erlitou are classified independently according to geographic area and then compared for similarities and differences. Finally, the relationship between the Erlitou society's social organization is summarized.

This paper selects burials with clear burial descriptions and pictures as samples, including 207 burials in Erlitou sites and 198 burials out of the Erlitou site (Table 26). Due to the poor preservation of burials in Erlitou site, many of which were damaged, many burials within the Erlitou site were excluded from the classification study in order to ensure the accuracy of the study and to examine the possible accompanying burial pattern.

5.2.3.1 Erlitou site

First of all, the correlation analysis of each element was conducted, and it was found that the element of area was less correlated with other factors, which means the area attribute has no significant effect on differences in burial behavior.

Table 27 The KMO and Bartlett's test result of Factor Analysis

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.59
Bartlett's Test of Sphericity	Approx. Chi-Square	3213.815
	df	91
	Sig.	0

Table 28 The result of Factor Analysis in Erlitou site

	Component		
	1	2	3
Number of bronze	0.971		
Bronze Jue	0.913		
Bronze drinking vessel	0.867		
Bronze weapon	0.819		
Jade	0.795		
Pottery		0.871	
Pottery serving		0.859	
Pottery cooking		0.799	
Pottery storage		0.787	
Total number		0.738	
Pottery Jue			0.897
Pottery drinking			0.83
Pottery he			0.713

A total of three factors were extracted from the factor analysis, which could explain a total of 76% of the variation in burial behavior. Factor 1 contains mainly bronze and jade. Such items are all ritual items, showing the special identity; factor 2 contains the pottery number and the total number of burial items, which may represent wealth ability; and factor 3 contains mainly drinking vessels, representing feasting activities and special rituals (Table 27,28).

Based on the factor scores of different burials in the factor analysis, the cluster analysis divided the burials into six groups (Figure 50). Firstly, group G1 is the most distinctive, featuring a very high factor 1 score, implying that this group contains a high number of bronze and jade artifacts and has very obvious differences from the other groups. The second group G2 is characterized by a large value of Factor 3, indicating the large number of pottery drinking vessels buried with it, while the third group G3 has more pottery but fewer jade vessels. The number of pottery vessels in the other three groups gradually decreases (Table 29).

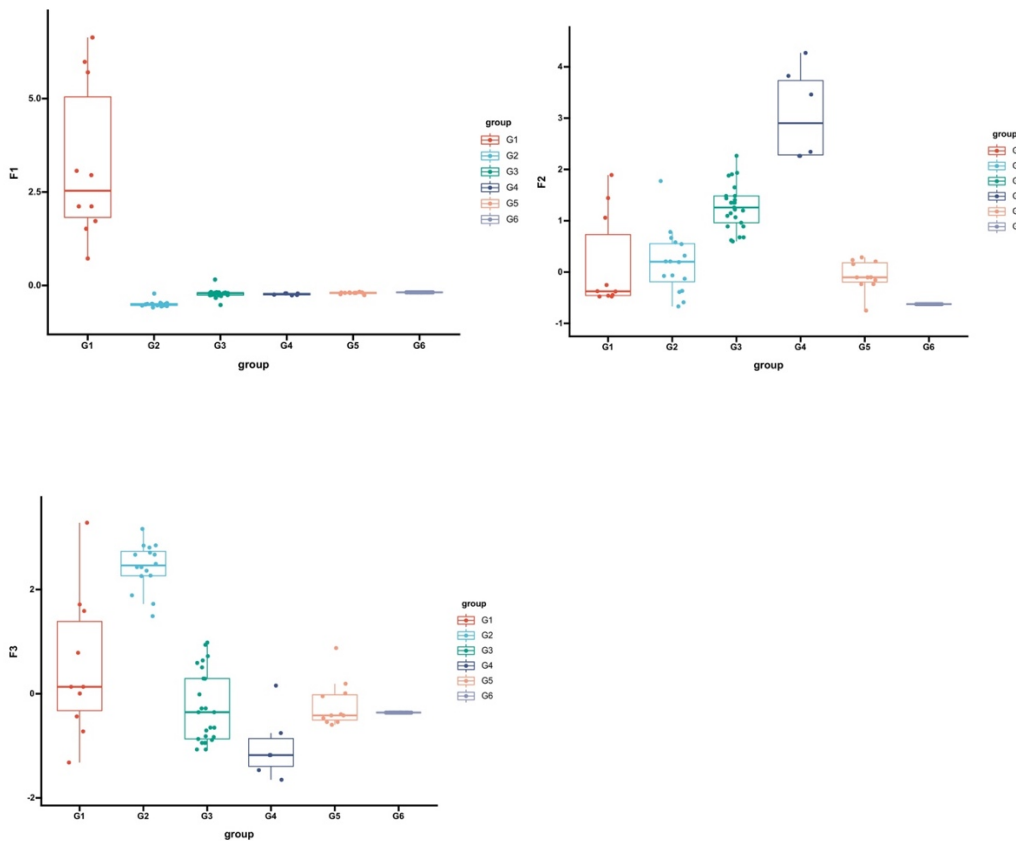


Figure 50 The factor scores of different groups

Combining the background of Erlitou culture with the previous studies on hierarchical division, the different groups could correspond to different social ranks and groups. Rank one is the top elite class of Erlitou, corresponding to group one. Groups 2 and 3 should correspond to the secondary elite class, with a large number of pottery items, particularly pottery drinking vessels, and the further stratification of two groups A and B represents the status of the secondary elite group, according to the jade. The other classes correspond to groups 4-6, representing the differentiation from the wealthy class to the commoner class.

Table 29 The information of different mortuary attributes in different burial groups

	Bronze vessels			jade			Pottery number			Drinking vessels		
	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
G1	4	1	2.1	4	1	1.8	8	0	4.3	4	1	2.3
G2	0	0	0	3	1	1.2	5	4	4.7	3	1	2
G3	0	0	0	0	0	0	12	4	7.3	3	0	2
G4	0	0	0	0	0	0	7	2	4	2	0	0.9
G5	0	0	0	0	0	0	2	1	1.3	0	0	0
G6	0	0	0	0	0	0	0	0	0	0	0	0

The main classification differences are some adjustments made to classes 2B and 3. The original criterion for classification was the absence of drinking vessels in class 3, but in the author's statistics, some of the class 3 burials also had drinking vessels, which would not meet his originally predetermined criteria. This paper examines the problem that the differences between groups are mainly in the composition of pottery types, i.e., the total proportion of drinking and serving vessels compared with cooking and storage vessels. The proportion of drinking and serving vessels is larger in Class B than it is in Class 3.

In addition, the same method described in this section is also applied to examine burials outside the Erlitou site.

5.2.3.2 *Yiluo Basin*

In the study of burials in Yiluo Basin, three factors were extracted by the factor analysis. Factor 1 contains information about the total number and type of pottery.

Factor 2 contains turquoise and bones, and factor 3 contains jade and area attributes (Table 30). Based on the same step, cluster analysis divided the burials into five groups, with Group 1 having a high number of pottery and turquoise and jade vessels. The average burial area is also the largest. It is the burial with the highest status and rank in the Yiluo Basin (Table 31). Then the following four groups of burials have no turquoise or jade, and the burial area and the number of pieces of pottery decrease in order. Groups 2 and 3 may represent the society's wealthier groups, whereas Groups 4 and 5 correspond to the two lower-class groups.

Table 30 The result of Factor Analysis in Yiluo Basin

	Component		
	1	2	3
Total number of pottery	0.868		
Pottery drinking vessels	0.827		
jue	0.626		
he	0.581		
Pottery serving vessels	0.572		
bones		0.931	
turquoise		0.929	
area			0.823
Total number of jade			0.72

Table 31 The information of different mortuary attributes in different burial groups in Yiluo Basin

	Pottery :max-min(average)	Turquoise /jade	Area: max-min(average)
G1	11-3; (7)	Yes	2.03-0.87; (1.45)
G2	9-3; (5.5)	0	2.54-0.9; (1.04)
G3	7-3 ; (5)	0	0.99-0.48; (1.045)
G4	4-1 ; (2.5)	0	1.1-0.78; 0.97
G5	1-0;(0.02)	0	1.29-0.4; 0.84

Overall, the Yiluo Basin burial classification criteria were primarily based on the number of burial objects and burial area. The highest rank of burials owned by the local chiefs were marked by turquoise or jade artifacts. There is a great similarity between

the burial practices in the Yiluo Basin and at the Erlitou site. Except for the absence of bronze, the types of burial objects and the corresponding burial systems are consistent with those in the Erlitou center, including the importance of jade or turquoise and pottery drinking vessels.

5.2.3.3. Zhengzhou Plain

In the analysis of burials in Zhengzhou plain, factor analysis summarizes two factors to explain the variation among burials. Factor 1 primarily explains the number of pottery pieces, while Factor 2 represents the jade or turquoise and burial area (Table 32). The burials are divided into three groups according to the factor scores, which also correspond to the three classes of society. Similar to the result in Yiluo Basin, Group 1 is the local elite who owned turquoise and jade and had a large burial area. The social status of the next two groups decreases in order. They are the wealthy class and the commoners (Table 33).

The mortuary practice in Zhengzhou plain reflects the lack of a tradition for bronze and drinking vessels, as well as a burial tradition comparable to that of central Yiluo. The Zhengzhou Plain reflects the absence of a tradition for bronze and drinking vessels and does not have a burial tradition like that of the central Yiluo region. Just the total amount of pottery and jade can be used to explain the differences between the tombs.

Table 32 The result of Factor Analysis in Zhengzhou Plain

	Component	
	1	2
area		0.846
total number	0.821	
Total number of pottery	0.955	
jade		0.941
serving	0.746	
storage	0.914	
turquoise		0.85

Table 33 The information of different mortuary attributes in different burial groups in Zhengzhou Plain

	Pottery: max- min(average)	Jade/turquoise	Area: max- min(average)
G1	6-0; (4)	1	2.46-1.72; (2.09)
G2	4-2; (2.7)	0	1.19-0.84; (1.07)
G3	1-0; (0.17)	0	1.09-0.3; (0.83)

5.3.3.4 Jinnan region and southern region

These two areas show obvious local characteristics in the form of burial: horizontal cave burial and vertical cave burial both occupy a certain proportion of all burials, which did not exist in the Erlitou site.

There is only one cemetery found in Jinnan region: Dongxiafeng cemetery. In the factor analysis, Factor 1 contains the burial area, turquoise and drinking vessels, which implying the labor income and sacrificial status, then Factor 2 contains number of pottery mainly which represents wealth capacity (Table 34).

Table 34 The result of Factor Analysis in Jinnan Region

	Component	
	1	2
area	0.955	
Total number of pottery		0.832
turquoise	0.967	
Pottery drinking vessels	0.898	
Pottery serving vessels		0.719
Pottery storage vessels		0.755

Such factor extraction shares the same results of the burial in Yiluo area. Based on cluster analysis, the burials can be divided into 3 types corresponding to the 3 ranks, while only a few pottery vessels were buried with the horizontal-cave burials (Table 35).

The southern regions only found some small burials and the number of pottery is enough for classification. The burials could be divided into 2 ranks and all burials have shown the low degree of social status.

Table 35 The information of different mortuary attributes in different burial groups in Jinnan and Southern Regions (1) Jinnan (2) Southern Region

	pottery: max-min(average)	Jade/turquoise	Area: max-min(average)
R1	3	yes	2.2
R2	4-2; (2.5)	0	1.23-0.95; (1.12)
R3	1-0; (0.46)	0	1.2-0.68; (0.89)

(1)

	Pottery: max-min(average)	Jade/turquoise	Area: max-min(average)
R1	6-5; (5.5)	0	1.5
R2	2-1; (1.32)	0	1.1-0.3;(0.78)

(2)

5.3.3.5 Summary

After analyzing the classification of burials and mortuary practice in different regions separately, the horizontal comparison provides an insight into the social organization of the entire Erlitou society in a wide region.

Table 36 The number of different ranked burials in the four phases (1) Erlitou site;(2) Yiluo Basin; (3) Zhengzhou Plain

Phase	1ST	2nd	3rd	4th
r2				1
r3	1	7	2	3
r4	4	13	4	1
r5	2	16	19	4

(1)

Phase	1ST	2nd	3rd	4th
r2			2	1
r4	1	1	3	
r5	1	11	3	9

(2)

Phase	1ST	2nd	3rd	4th
r2			2	1
r4	1	1	3	
r5	1	11	3	9

(3)

A cross-regional comparison in different regions shows that the top elite burials at

Erlitou Site were the most luxurious and dominated over the other burials. This indicates that Erlitou was the center of the entire Erlitou culture and also had the most complex social structure, probably with five levels of social differentiation. Corresponding the local burial practice to the Erlitou burials, we can see that the scale of the local chief's burials is equal to those of the secondary elite, while the rest of the burials are equal to those of the wealth group and the commoners in the Erlitou site (Table 36). Furthermore, through the examination of local burials, there is hierarchical stratification in all the sub-regions. The distribution of burials in different periods also shows that the highest rank of burials in the local area all belong to the third and fourth periods, indicating that social stratification gradually increased in the third and fourth periods.

Therefore, looking at the whole Erlitou society, the Erlitou site has a more complex social structure than the local regions and occupies a central and superior position in the whole Erlitou society. As for the complex relationship between the central and local levels, a comparison of burial assemblages reveals that the Yiluo basin shared the same ritual system as the Erlitou site, while other localities maintained their own local characteristics. The Yiluo area values jade (turquoise) and ceramic drinking vessels highly, whereas other areas only value jade and turquoise. Such burial customs and the Erlitou center's identity recognition system influenced these three regions, and chief-like leaders in these three regions followed such a system to demonstrate their political identity leadership status.

5.2.4 The social system of Erlitou society

Erlitou was already a highly stratified society that formed a wide area of early states dominated by the Erlitou site. By analyzing the characteristics of settlements and the mortuary practice in the whole Erlitou society, Such integration and cultural expansion in a wide area are driven by different motives.

The entire Erlitou society was clearly hierarchical, with a densely populated and stratified social organization within the Erlitou site, with inhabitants engaged in

agriculture and various crafts activities producing what the elite required and a simpler social structure in the local regions.

The Erlitou Center's urban planning and burial behavior have clearly reflected the society's organizational system in the urban center. First of all, the elite had obvious political and economic privileges, occupying the main functional areas in the Erlitou Center. Further hierarchical and functional divisions began to appear within the elite group. The differentiation of burials represents such hierarchical divisions in social ranks. On the other hand, the functional division is supported by the evidence of attached craft workshops. The enclosed craft workshop was located in the southern part of the palace area, and the bronze workshops were located in District 4. Such a dedicated area for craft production shows that the strong central elite power had a profound influence on the arrangement of the urban center and that in order to manage these craft workshops, a professional management group was necessarily divided to supervise and control the production and distribution of bronze and turquoise, showing the professional differentiation within the ruling class. Second, the commoner and smaller burials are located in the western and northern areas of the site, but there is little data on these areas. However, the development of the Erlitou site could not be separated from a large number of population migrations. Erlitou was probably first formed due to the migration of the surrounding population, and the early migrants came from different small blood groups rather than from a community with blood ties (Zhongguo, 2014). The initial formation of the urban center was a population grouping of different groups of people constrained by a common urban plan, so it broke the basic social structure of the late Neolithic through kinship.

Like the most stratified societies, the elite controlled various resources for the whole society. For example, they held the central functional areas of the central cities, controlled the production of valuable handicrafts, and acquired porcelain through long-distance exchange. Externally, they were motivated by the acquisition of resources to continue their cultural expansion and formed a strong, wide-area collective, at least in the third phase of Erlitou.

At present, Erlitou does not show a clear religious tendency but rather a more

secular attitude in the burials, with bronze, jade, and drinking vessels as status symbols and hierarchical distinctions to show strong feasting ability and ritual power. In addition, prestige vessels played an important role in maintaining the Eritrean political system as well as the common ideological system.

5.3 Pottery specialization and production system in Eritou society

This section analyzes the pottery production system in Eritou society. It includes the study on craft landscape of pottery in Eritou site based on direct evidence; the standardization and differentiation of pottery from Eritou culture, especially the drinking vessels in the large territory; and the consumption and exchange of different pottery. The white pottery will be especially studied to investigate the production of prestige pottery. Finally, based on this evidence, the pottery production could be summarized in the final part.

5.3.1 Direct evidence: the craft landscape of pottery production in Eritou site

Compared to the Taosi site, less direct evidence of pottery production has been found at the Eritou site (Figure 51). The pottery workshop has not been identified yet at the Eritou site, but some related remains have been found. Seven kilns were discovered from 1959 to 1978, including one in Phase 1 (IVY12), which was located inside the bronze workshop but is fragmented and has no published images, five in Phase 3 (IXY1, IXY2, IVY2, IVY3, and IVY12), of which only IXY1 has been published, and one in Phase IV (VY1). These kilns are similar in shape and generally consist of grates and a fire chamber, but they are not as well preserved as the pottery kilns at the Taosi site (Li, 2017). However, the kilns found are mainly in Districts 9 and 4. The kilns in District 4 are located inside the bronze workshop area, which should serve the bronze production activities as well as produce the ceramic modes, implying that pottery production does not require a separate production organization (Zhongguo,

2014). In District 9, the two kilns found so far were 2 meters apart, and a house was found around them, but no other tools or debris were found in the surrounding area. The pottery kiln found in District 5 has a clear description of its structure. Only a small number of pottery pads were found at the site, which provided little information on the location of pottery production and the detailed production process (Zhongguo, 1999; 2014).

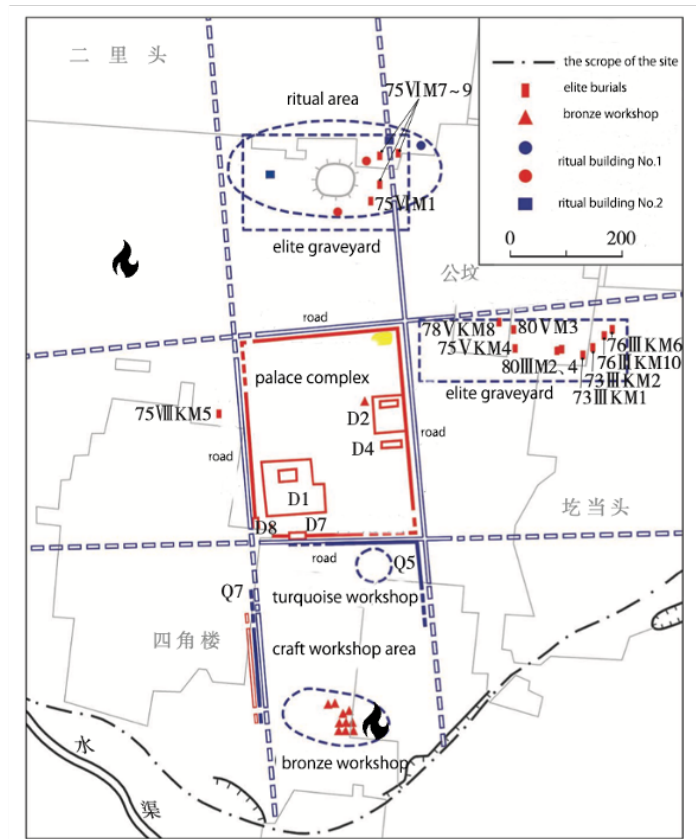


Figure 51 The distribution of craft production units in Erlitou site(based on Zhao and Zhang, 2021)

However, compared to the size of the population at the Taosi site and the scale of Taosi, it is unusual that the Erlitou site, an urban center with such a large number of inhabitants, only contains these few pottery kilns and tools. The density of pottery kilns contained in the area is much lower than that of the Taosi site, and the tools are more disparate. There is reason to assume that there were no large-scale pottery workshops in the central area of Erlitou, and the existence of two pottery kilns in District 9 does not allow a judgment on the specific organization of production units. Therefore, pottery production activities, as opposed to other crafts such as bone, bronze, and

turquoise, were not concentrated in the central area of the Erlitou site but were probably located in the marginal area or the rural areas, supplying the large demand at Erlitou Center. Similar examples can be found in other ancient states; as previously stated, in early Mesopotamian states, ordinary pottery production was located outside the center core area. Such workshops supplied pottery products to the urban center and had a high level of specialization. In the latest academic conference report, Zhao(2022) announced the latest excavation results at the Erlitou site. They found a suspected pottery production workshop at the northwestern edge of the site and discovered a concentrated distribution of pottery kilns and semi-finished pottery items. Although specific information on pottery products and workshop layout was not released, it provides support for previous arguments. That is, pottery production workshops existed at the edge of the site to meet the demand of the urban population for pottery.

In summary, from the above direct evidence, it can be presumed that the central area of Erlitou has given way to a more functional area such as political facilities and luxury craft production, and that large-scale pottery units did not exist in the area currently excavated at the Erlitou site, but the pottery was most likely produced on a large scale in marginal and rural areas and imported into the urban center.

5.3.2 Indirect evidence: the standardization and differentiation of pottery in Erlitou culture

According to the analysis of the settlement patterns inside as well as outside Erlitou in the previous section, pottery can represent the consumption patterns of different social groups according to different excavation contexts. Among them, District 5 is the palace area dedicated to the elite for living or ritual activities (Zhao, 2020), so the pottery excavated here represents the consumption of the elite. The small walled areas in Districts 4 and 5 were bronze production and turquoise production workshop areas, respectively, so the pottery in this area represents the consumption of people involved in luxury craft production. The other zones represent general consumption areas.

A. Clay composition

The data in this section are mainly from the pottery data published in the report and from previous studies (Zhongguo, 2014). These data are further examined using PCA and a comparison of whether there are significant differences between different types of pottery and different excavation contexts.

The pottery found at the Erlitou site can be broadly categorized into common pottery (red, gray, etc. in appearance), white pottery, and porcelain, depending on the material.

Figure 53 shows significant differences in the chemical composition distribution among three different types of pottery. The differences are mainly manifested in the fact that common ceramics contain significantly higher amounts of MgO, Fe₂O₃, and K₂O, while containing lower amounts of Al₂O₃ and TiO₂, compared to white pottery and proto porcelain. Additionally, the SiO₂ content of white pottery is slightly lower than that of proto porcelain.

Based on the above result, a principal component analysis is conducted on the chemical composition of the clay. The results of PCA on EDXRF data also show the clay in these three types of pottery is different. The common pottery tends to contain more CaO, K₂O, and Fe₂O₃, while the white pottery contains more Al₂O₃, and the porcelain group tends to contain more SiO₂ (Figure 53).

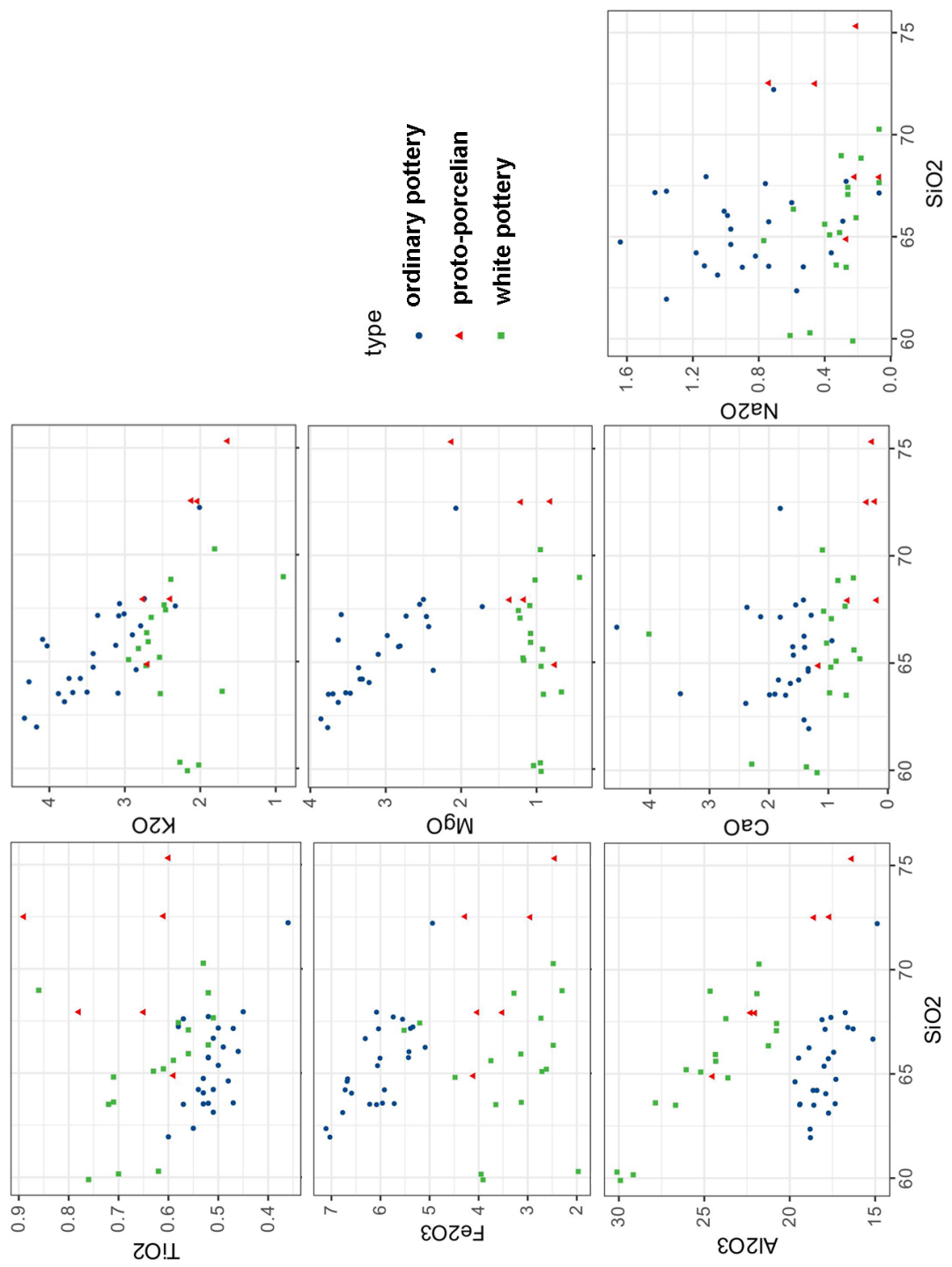
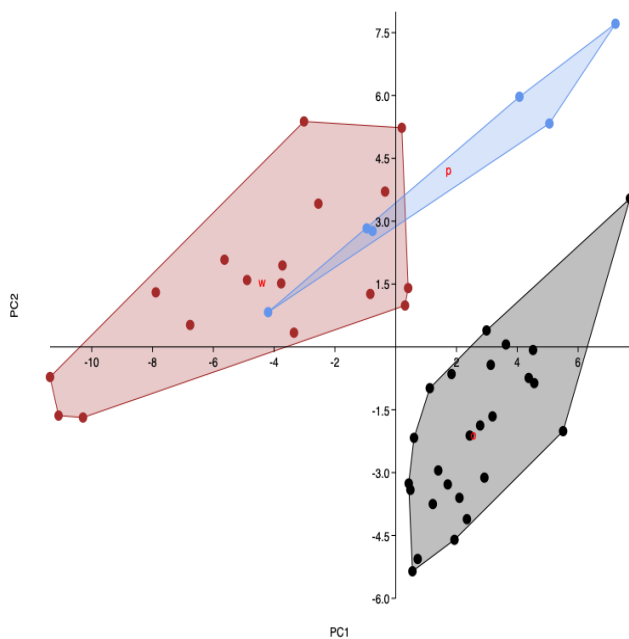
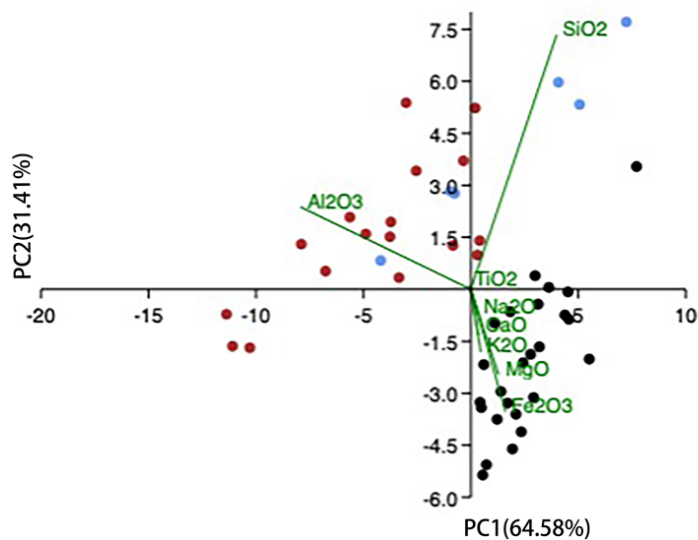


Figure 52 The distribution of each chemical component of pottery from Eritou site



Blue: proto-porcelian; Red: white pottery; Black: ordinary pottery.

Figure 53 The results of PCA on EDXRF data

Furthermore, in the MANOVA test (Table 37), there is a significant difference between special pottery and ordinary pottery, but although the difference between porcelain and white pottery is significant, the value is smaller than the one for special pottery and ordinary pottery, which shows the degree of difference is smaller than the difference between special pottery and ordinary pottery. The study continued to use MANOVA to test whether there is a special selection of raw materials in the clay for

different functions. The result shows that the drinking vessels have significant differences from the other functional (storage, cooking, and serving) vessels, but this is due to the fact that the majority of the white pottery was drinking vessels, which may have a special selection of materials (Table 37). In contrast, the samples from the other three categories did not show the same behavior of selecting the clay according to its function.

Table 37 The result of MANOVA test of EDXRF data from different contexts

	ordinary	workshop	palace	
ordinary				
workshop	0.0000***			
palace	0.0000 ***	0.0020**		
	storage	cooking	serving	drinking
storage				
cooking	0.1570			
serving	0.2773	0.4038		
drinking	0.0000***	0.0011**	0.0008***	

*p<0.05 ** p<0.01 ***p<0.001

In addition, the compositional results from the icp-AES analysis of the general pottery in the previous study were used to examine the spatial and temporal variation and differences in the ordinary pottery (Figure 54). These pottery samples are mainly from Area 5, 3, 9, and 4 of the site, representing the palace, residential areas, and workshop areas of the site, respectively, and can effectively represent different consumption patterns. These samples also cover the entire phase from Erlitou 1 to 4, representing the variation of pottery raw materials at different temporal dimensions.

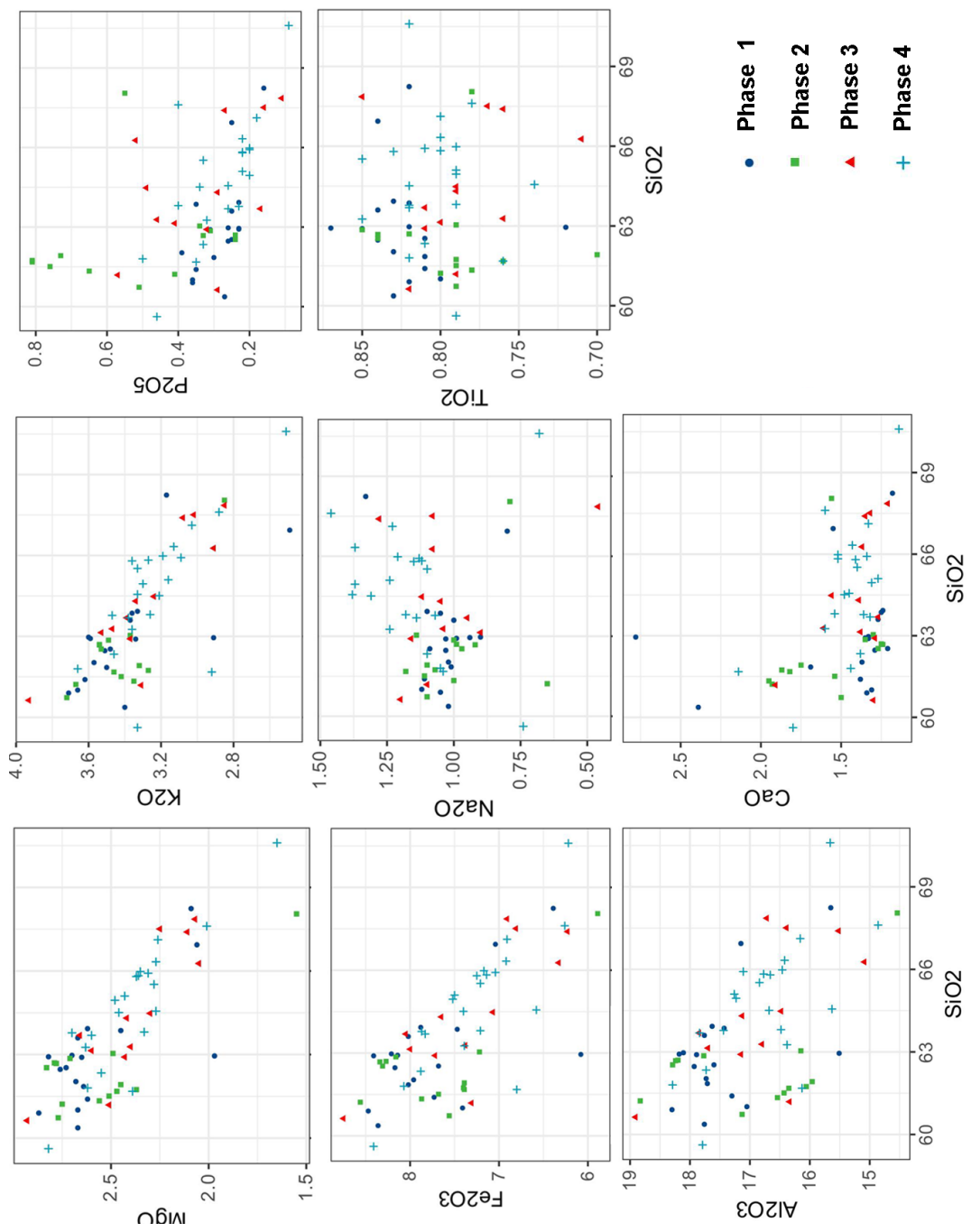
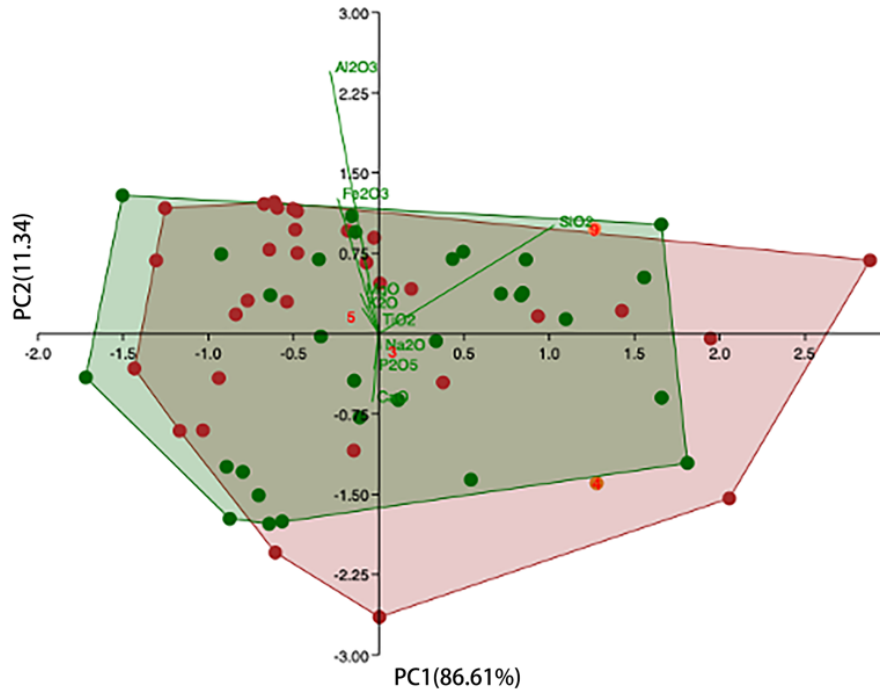
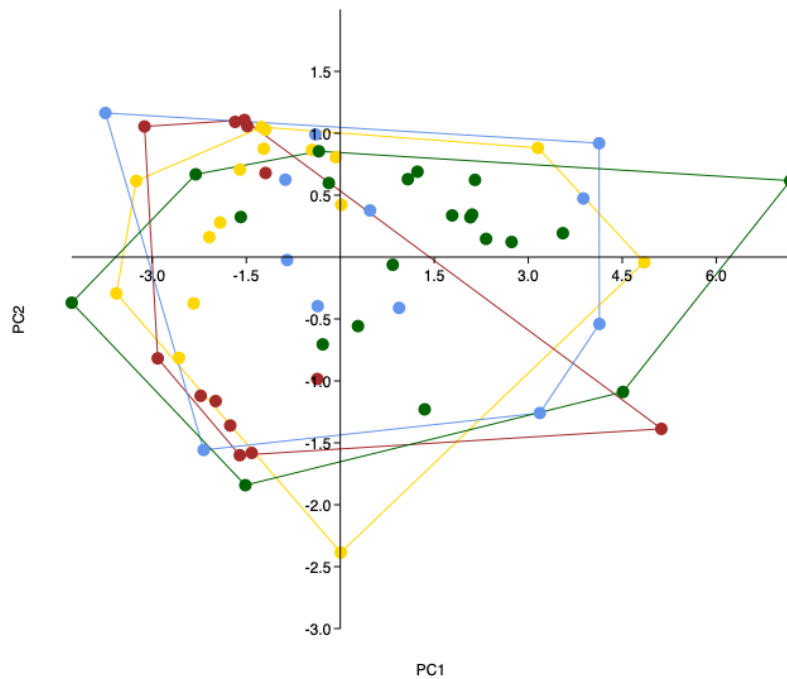


Figure 54 The distribution of each chemical component of pottery from Erlitou site in 4 phases



Red: Area 5; green: Area 3; orange: Area 9,4.



Yellow: phase 1; Red: phase 2; Blue: phase 3; Green: phase 4.

Figure 55 The results from the icp-aes analysis

The distribution of each chemical component of clay shows little apparent difference between different phases as depicted in Figure 54. The results of PCA for these data showed a large range of overlap between samples from different regions,

especially between Area 3 and 5, demonstrating their similar raw material composition(Figure 55), as for the phase variation, the results found that there is no obvious variation in clay changes during the 4 phases(Figure 55).

The results of the MANOVA test for sample also showed no significant differences between the samples from these two districts. In the temporal variation dimension, the results also did not show a significant separation among the four phases, and data from all four phases had a large overlap range. The MANOVA test showed some differences between the samples from only the second phase and the other phases, showing the possible diverse recipes of clay in this phase(Table 38).

Table 38 The MANOVA result of icp-aes analysis data from different contexts

Area	Area 5	Area 3
Area 5		0.2818
Area 3	0.2818	

(1)

Phase	1 st	2 nd	3 rd	4 th
1 st		0.0105**	0.1613	0.2406
2 nd	0.0105**		0.2862	0.0014 **
3 rd	0.1613	0.2862		0.1834
4 th	0.2406	0.0014**	0.1834	

(2)

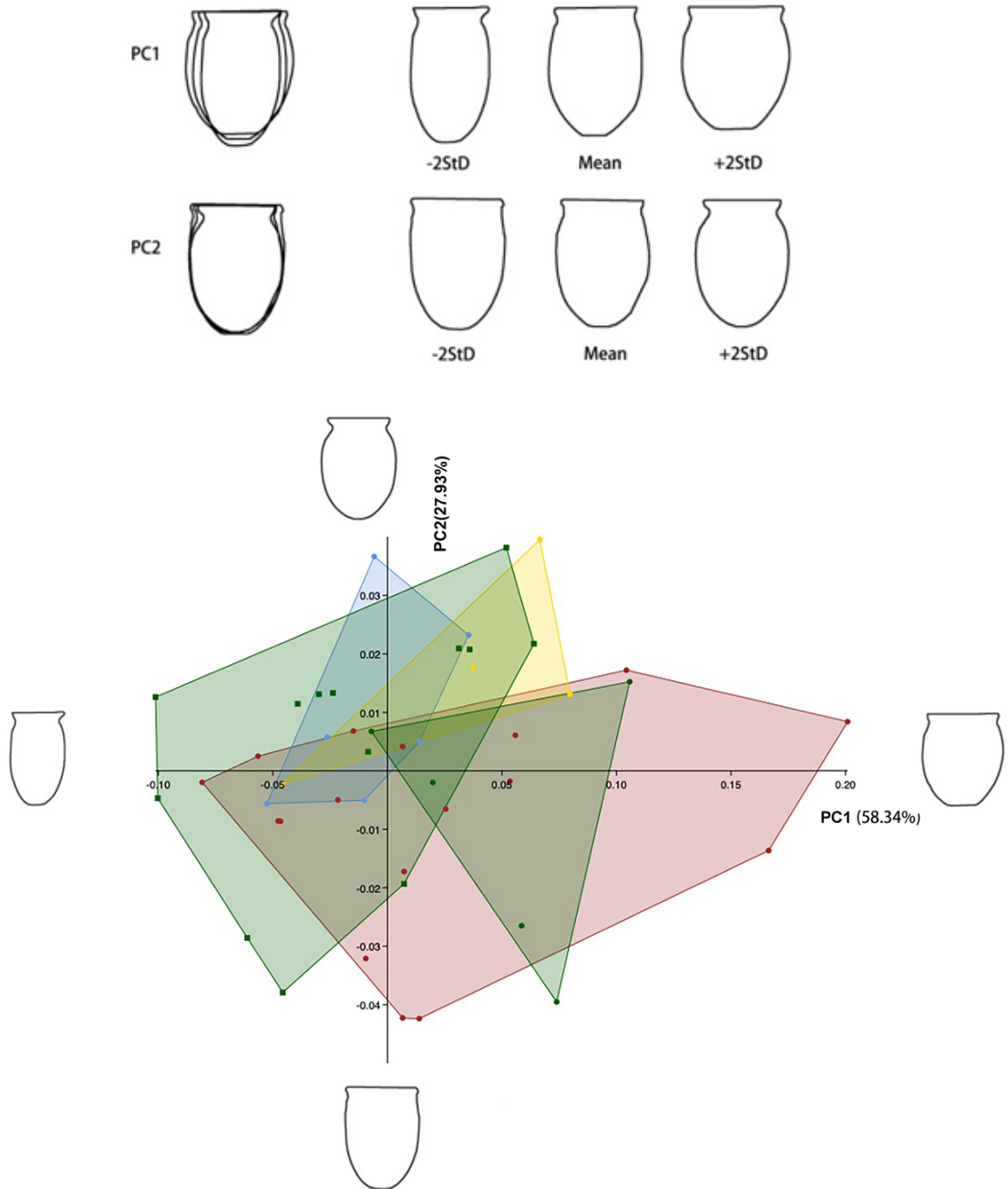
*p<0.05 ** p<0.01 ***p<0.001

B. Morphological and metric analysis

Cooking jars with deep abdomen

Cooking jars with deep abdomen is one of the typical cooking vessels of the Erlitou culture and was excavated at the Erlitou site in all general living areas of the non-burial site. The temporal distribution also covers through the Erlitou Culture Phase 1 to Phase 4.

The EFA has calculate the shape variance of the Jars: PC1(58.34%) is mainly the change of bottom shape and abdominal width; PC2(27.93%) mainly explains the degree of abdomen bulge and changes in the mouth edge(Figure 57).

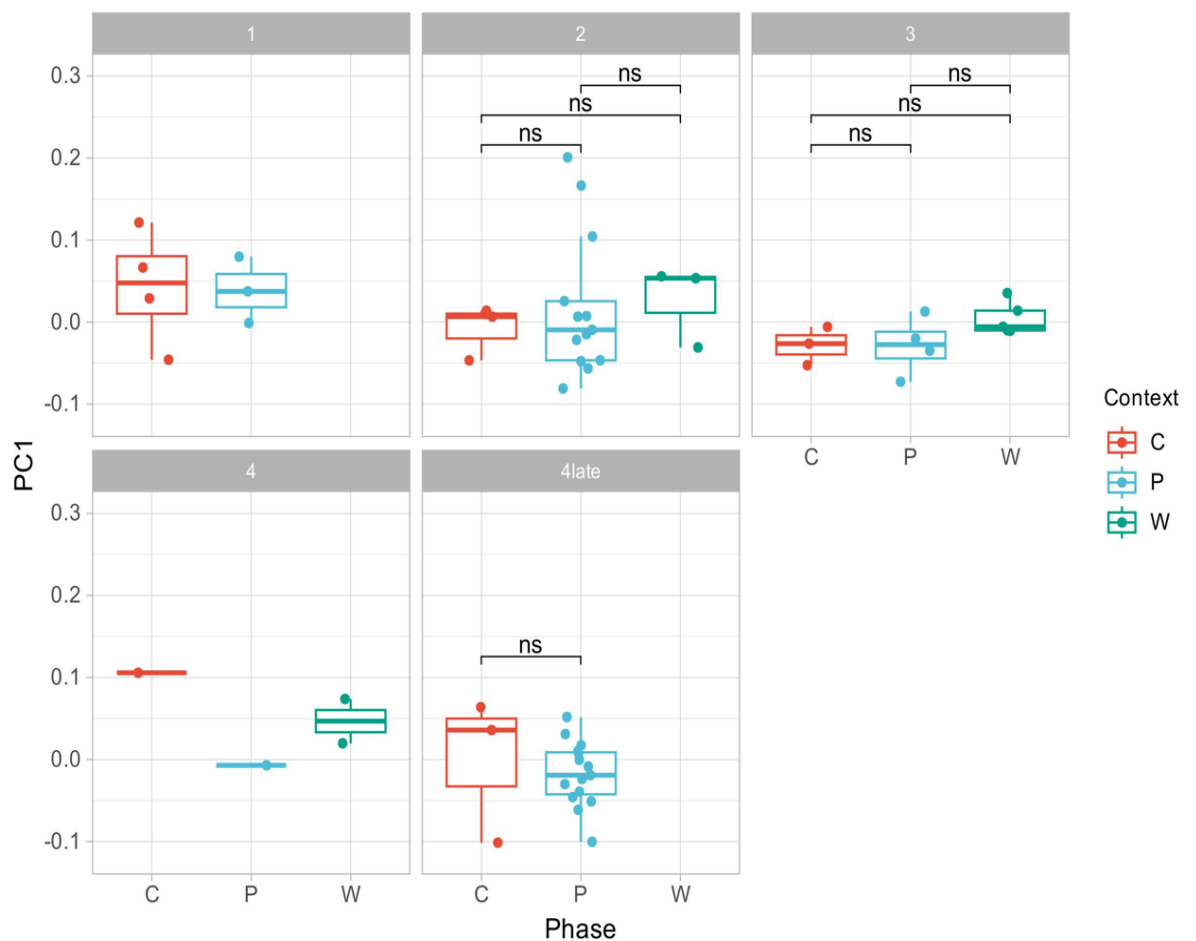


Yellow: phase 1; red: phase 2; blue: phase 3; green: phase 4; square: the late stage of phase 4

Figure 56 The result of EFA and PCA on morphological attributes of Jars (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The results show the trend of shape change in different phases (Figure 56). The range of shape change from phase 1 to 2 suddenly became larger, mainly showing a

large change in PC1, with most samples possessing smaller values of PC1. This change shows that the overall shape during this phase becomes thin. The result then shows a clear standardization trend with a smaller range of change by phase 3. The samples concentrated in the smaller range of PC2 indicate changes in rim. Then the shape becomes more diverse in phase 4. The samples from the late stage in phase 4 may be responsible for the diversification trend. The variation in the sample of the early stage remained within a small range, while the sample of the late stage produced a variation that caused the whole trend in phase 4.



Phase 4: the early stage of Phase 4; Phase 4 late: the late stage of Phase 4

C: Commoner context(area rather than Palaca and workshop area); P: palace area; W: workshop area

Figure 57 The distribution of PCA result and Anova result of Jars (PC1)

The ANOVA test for PC1 alone showed the variation of the samples in different

areas over different phases (Figure 57). There was no significant difference between the pottery from different areas. The palace area in Phase 2 showed a significant diversity compared to the commoner area and workshop areas, then showed a clear trend of standardization in Phase 3, and the degree of variation in the commoner and workshop areas also became smaller in the third phase, but the change was not significant. In the early part of Phase 4, pottery from the commoner area could not be compared due to the small sample size, and the palace area and workshop area showed similar variation as in Phase 3, while in the late part of Phase 4, both the commoner area and palace area showed significant diversity. PC2 also showed a similar situation. This sudden variation in shape, as mentioned above, may be due to the fact that the late Shang group gained control of the Erlitou site, bringing a new variety of jars.

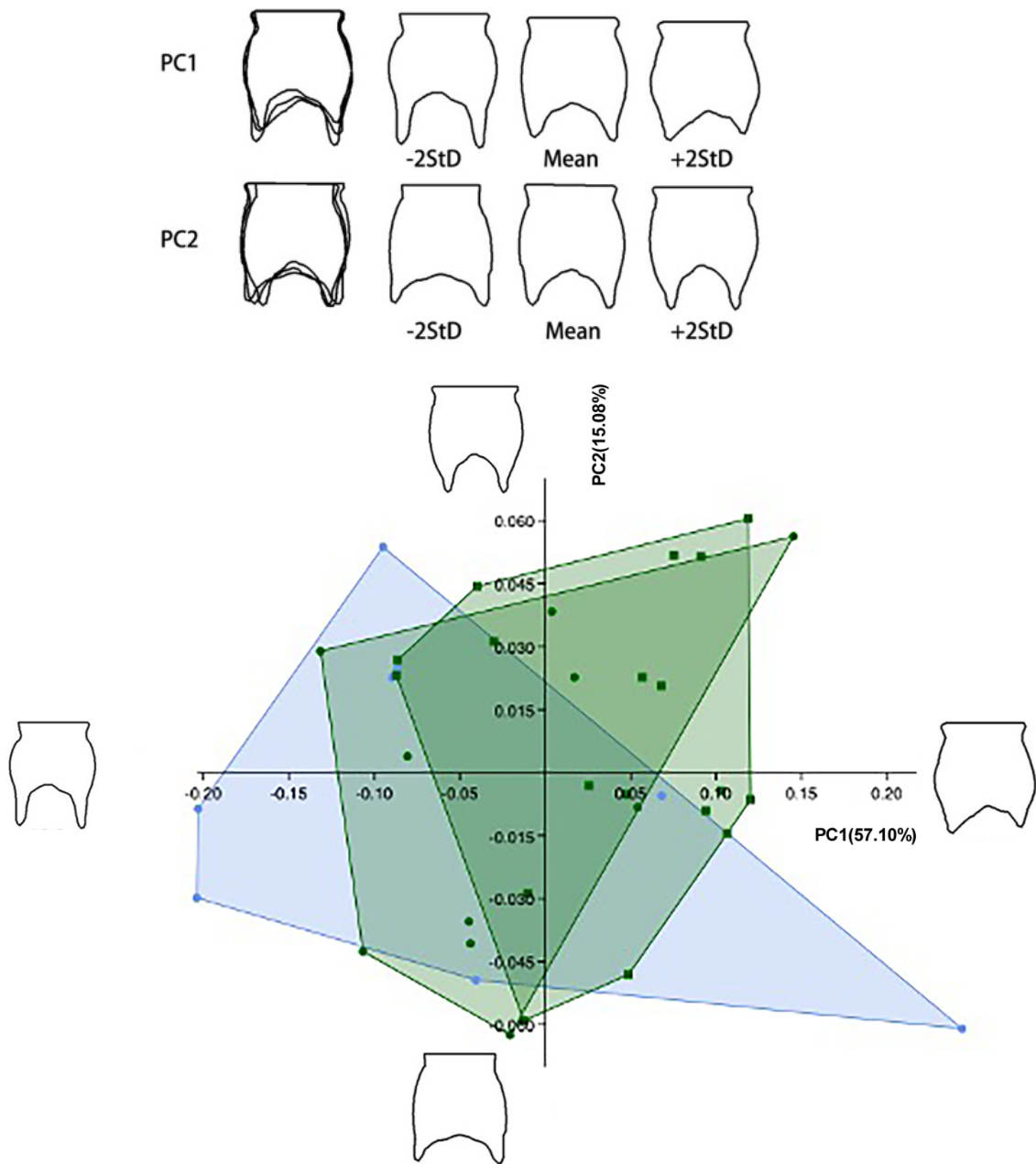
Table 39 The CV results of Jars *with deep abdomen*

N=367	1 st	2 nd	3 rd	4 th	4 th late
palace	15.67	16.65	8.28	10.09	17.35
workshop		9.10	7.06	13.86	16.37
commoner		9.34	8.23	11.08	11.89

The investigation on the CV of pottery's metric dimension has similar results to the shape studies (Table 39). The size change of the palace area in the first and second phases is much greater than that in the workshop and common area. In phase 3, all the jars have shown a trend of standardization, and the degree of variation has become smaller, especially in the palace area. In the fourth phase, the changes increased slightly, and the degree of variation in the commoner and workshop areas increased significantly compared with the palace area.

Cooking Li

Li is a common cooking vessel introduced to the Erlitou site in the late phase for daily use and is not found in the burials. It appeared in the Erlitou site from the third phase. At first, it did not appear in the palace area. Li was found in the palace area only after Phase 4 but is still present in large quantities in the commoner and workshop areas.



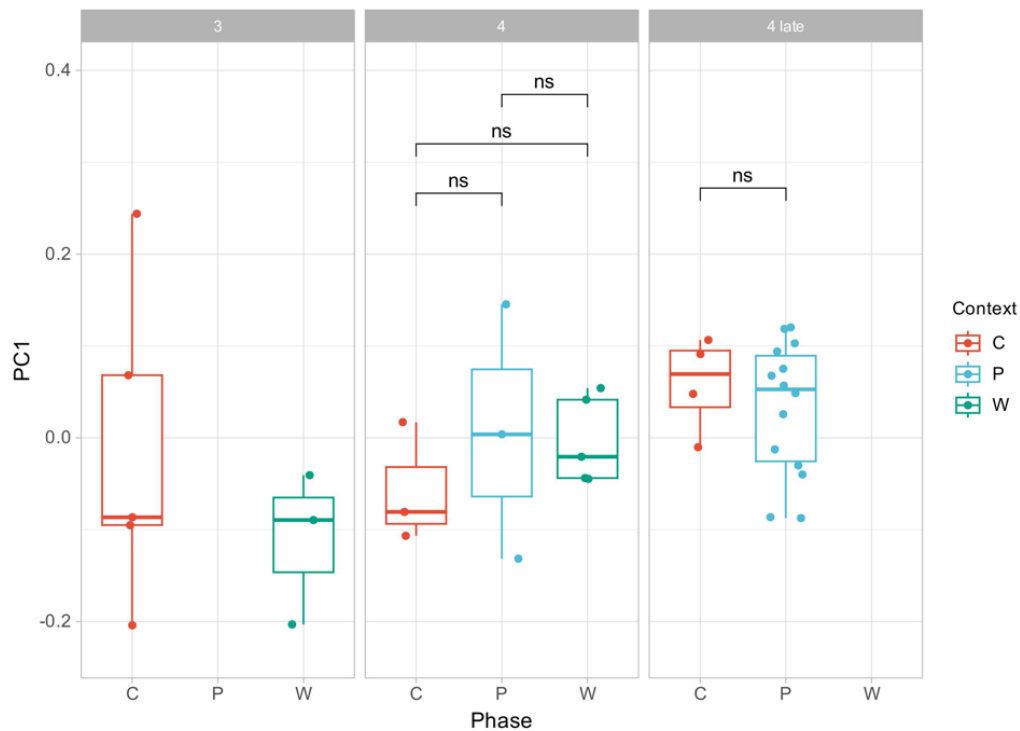
Blue: phase 3; green: phase 4; square: the late stage of phase 4

Figure 58 The result of EFA and PCA on morphological attributes of Li (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The EFA has calculate the shape variance of the Li: PC1(57.10%) is mainly the change of legs; PC2(15.08%) mainly explains the changes of belly and degree outward. The result shows that, from phase 3 to 4, the overall variation of Li did not standardize with its localization in Erlitou site. On the contrary, the PC2 has changed a lot during this phase, indicating the emergence of a group of Li with slightly bulging legs and a

higher crotch. Then a trend towards diversification has emerged(Figure 58).

In the separate ANOVA tests, there is no significant difference in PC1 among the areas (Figure 59). In Phase 3, the degree of variability is much greater in the samples from residential areas than from workshop areas. The samples in the palace area in phase 4 show the greatest variability, in contrast to the workshop area, which remains relatively small. PC 2 also shows a similar situation. It shows that overall, li from different areas are not significantly different and have a greater degree of variability.



C: Commoner context(area rather than Palaca and workshop area); P: palace area; W: workshop area

Figure 59 The distribution of PCA result and Anova result of Li (PC1)

In terms of size, the results of the CV examination are also similar to the results of the shape examination. Overall, the values of cv are all above 20%, and most of the samples are around 30%, showing a large degree of variation (Table 40). The degree of variation is less in the workshop area. This may be due to the inherent usage habits maintained by particular groups, but both the commoner and palace areas show a higher CV than the jars in the same phase. Such a trend of variation implies that new groups constantly bring the Li into the Erlitou site, and finally it has entered the palace context.

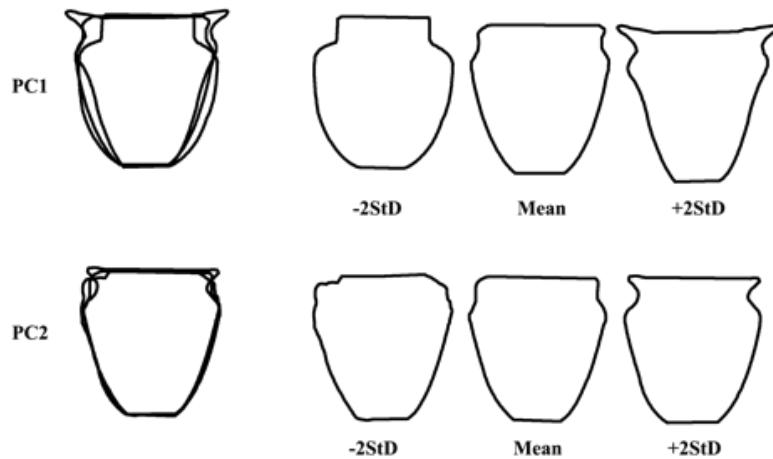
However, as a cooking vessel, Li has not become mainstream, mass-produced cookware and continues to be produced in a decentralized manner.

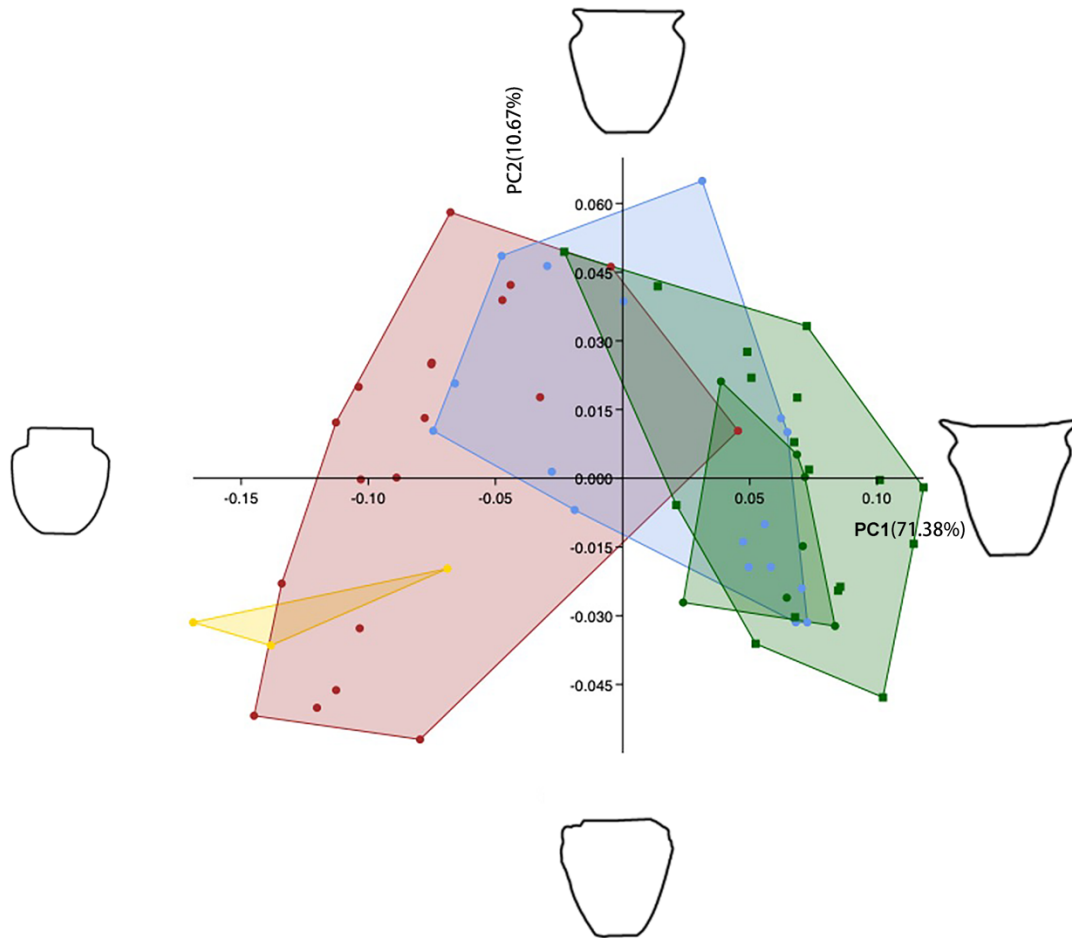
Table 40 The CV result of Li

N=91	<i>Li</i>		
	<i>3rd</i>	<i>4th</i>	<i>4th late</i>
commoner	17.23	36.18	28.67
palace		26.25	31.60
workshop		34.85	20.33

Storage Zun

The large-mouthed Zun is a type of storage vessels from the Erlitou culture. In previous studies, some of the residual traces of the Zun have been studied to suggest that part of its function was to ferment and store alcohol. The Zun appeared in different contexts including the palace area, the commoner area, workshop area, and mortuary context.



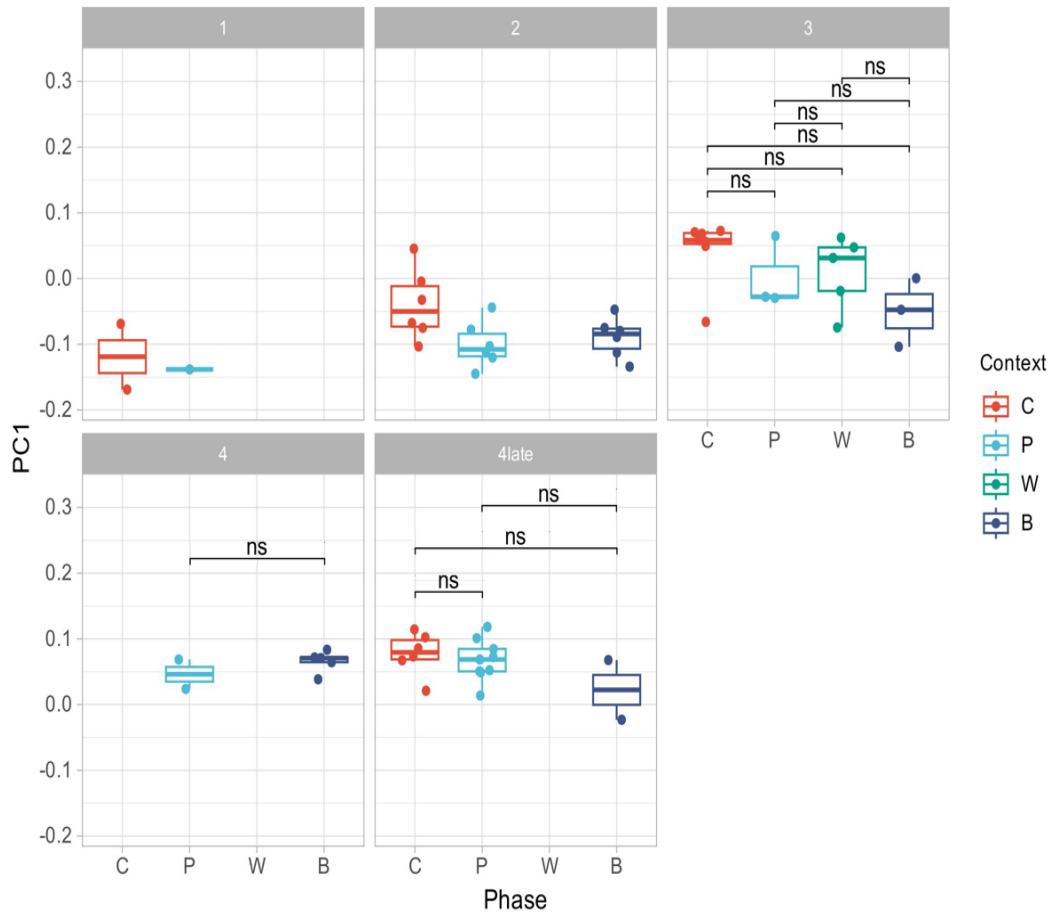


Yellow: phase 1; red: phase 2; blue: phase 3; green: phase 4; square: the late stage of phase 4

Figure 60 The result of EFA and PCA on morphological attributes of Zun (1) the shape variation implied by EFA ; (2) the PCA results of EFA

In terms of shape examination, the two components derived from EFA together explain 82.06% of the shape variation, with PC1 accounting for 71.38% and examining mainly the variation in the shoulders as well as the base of the Zun, while PC2 occupies 10.67% and examines mainly the variation in the width of the mouth rim of the Zun (Figure 60). The small sample of Phase 1 resulted in a small range of trends. While Phase 2 shows a clear trend of diversification in shape and produces a substantial increase in both PC1 and PC2 values, implying the rim of the Zun becoming larger. The PC1 values continue to increase in Phase 3 and the range of variation in the overall shape becomes smaller. As for the variation trend, from phase 2 to phase 4 early stage, the Zun continues to be standardized and re-diversified in the phase 4 late stage.

The results of the Anova test on the individual PC values proved that there was no significant difference in the PC1 between the different context (Figure 61). And there is no significant trend of standardization. The result of Phase 4 late stage also shows the varied trend. The range of variation in the commoner context is greater than that in other areas. The Zun in the burials maintained a trend of low variation in PC1.



C: Commoner context(area rather than Palaca and workshop area); P: palace area; W: workshop area; B: burial

Figure 61 The distribution of PCA result and Anova result of Zun(PC1)

Furthermore, the CV from phase 2 to phase 4 did not change dramatically in the size examination. However, the diversity in the palace area is very obvious from phase 2 to phase 3(Table 41). The variation of other area is relative large. However, the CV in the Phase 4 late phase shows a different trend from the shape attributes. The lower CV in this phase indicated the samples' rim is more standardized. However, it does not exclude a higher degree of variation in other parts of Zun.

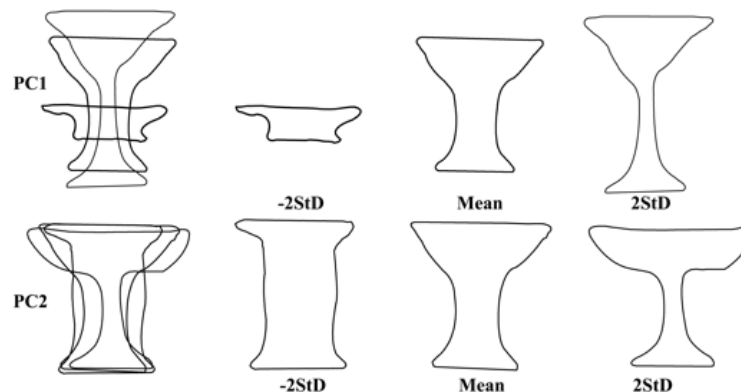
Table 41 The CV result of Zun

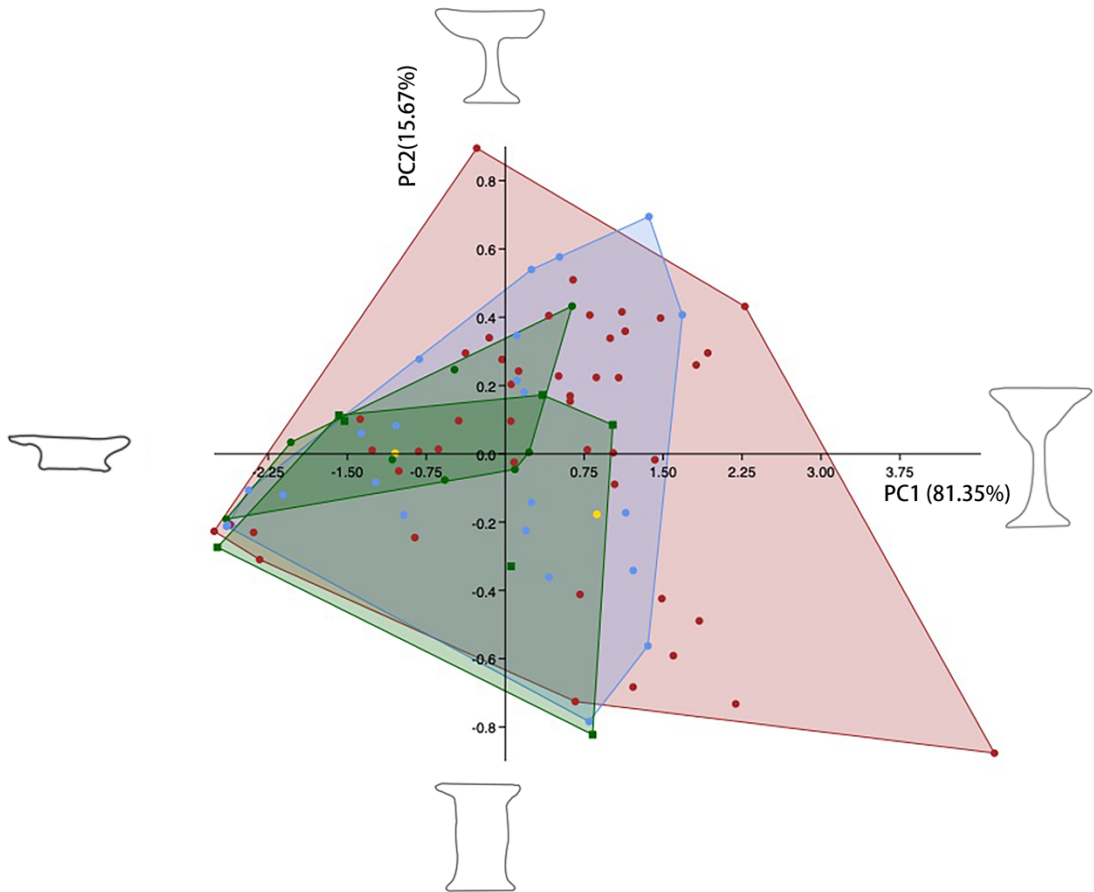
N=91	2 nd	3 rd	4 th	4 th late
Burial	9.32	21.69	15.13	?
Palace	22.16	20.22	25.48	15.63
commoner	12.79	17.54	23.78	12.27

Serving dou

Similar to the Taosi culture, the Dou is a common serving vessel of the Erlitou culture and is often found in feasting activities and mortuary practice. In Erlitou, Dou appears in different contexts. The EFA has calculated the shape variance of Dou: PC1 (81.35%) is primarily the modification of height; PC2 (15.67%) mainly explains the changes in depth in the upper body.

Figure 62 also shows the variation in the shape of Dou in different phases. The second phase shows a clear diversity; the range of variation becomes tremendously smaller in the third phase and continues to become smaller after the fourth phase, showing a continuous trend of standardization. When it comes to the late stage, the variation becomes larger again. Furthermore, the smaller PC1 values lead to a reduction in the range of variation, indicating the Dou becomes shorter through the phases.



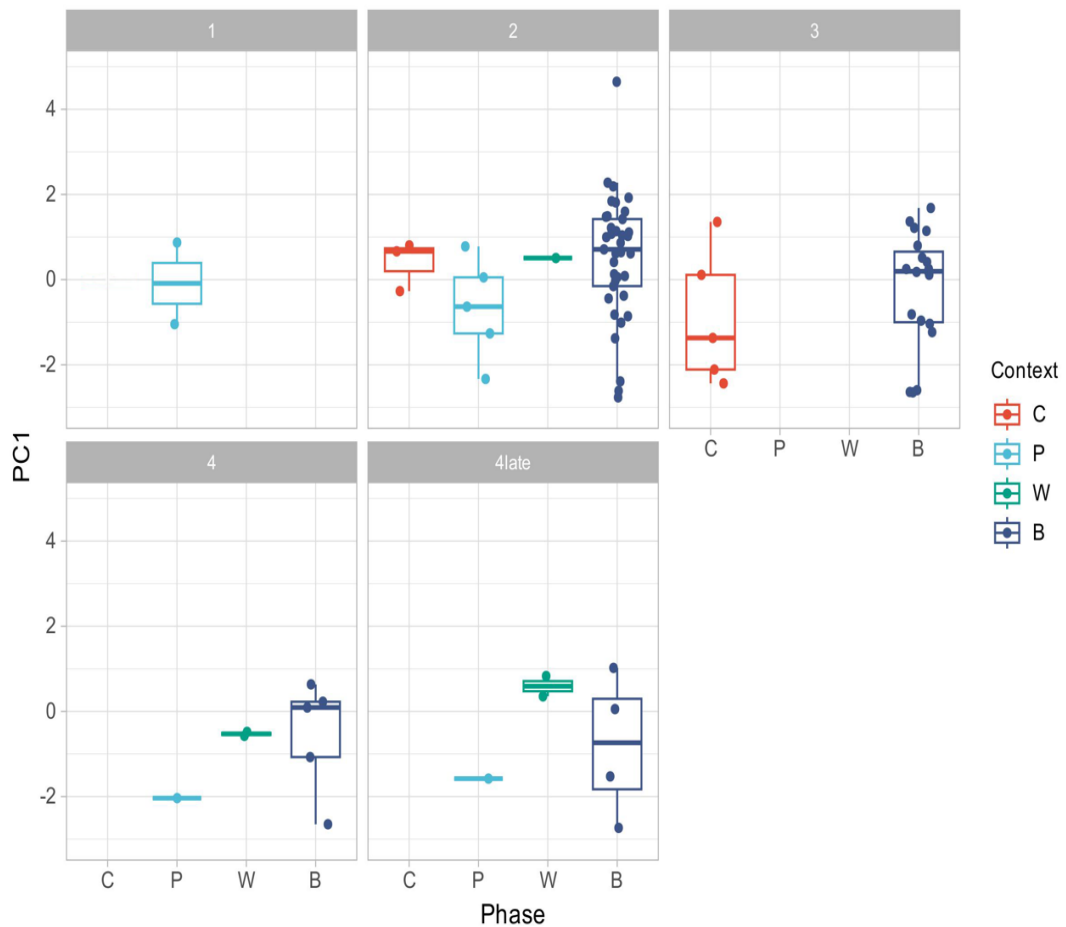


Yellow: phase 1; red: phase 2; blue: phase 3; green: phase 4; square: the late stage of phase 4

Figure 62 The result of EFA and PCA on morphological attributes of Dou (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The separate PC examination illustrates that the Dou does not differ significantly across different contexts (Figure 61). However, the degree of variation is significantly different across contexts. The samples in the burials were slightly larger and also showed the most diversity. The specific standardization will have to be further examined in the next section.

The CV results of Dou from different contexts show the same situation as the shape attributes (Table 42). The CV in palace, workshop and commoner area has shown standardized trend from phase 2 to 4 early stage but the Dou in burials tends to have larger variation. The CV shows the kind of larger variation in the late stage of Phase 4.



C: Commoner context(area rather than Palaca and workshop area); P: palace area; W: workshop area; B: burial

Figure 63 The distribution of PCA result and Anova result of Dou (PC1)

Table 42 The CV result of Dou

N=106	1 st	2 nd	3 rd	4 th	4 th late
palace	13.66	17.90	16.61	11.87	23.21
workshop		13.16	11.88		
commoner		51.43			13.77
burial		11.31	23.95	17.17	16.96

In summary, the examination of size and shape attributes of the above four kinds of daily pottery shows that the degree of variation varied in the different phase of Erlitou site. The shape attributes of deep-bellied Jar, Zun and Dou share a common trend of change: the phase second is more diverse, and there is an obvious standardization trend in the third and early stage of fourth phase, and the degree of variation becomes larger

again in the late stage of phase 4. On the other hand, Li, as a type of foreign vessel, in the process of localization, did not show an obvious trend of standardization. As for the size CV investigation, except for the rim of Zun, the trend of size change of other vessels is consistent with the results of shape inspection.

Drinking vessels

The drinking vessels had a special social significance in Erlitou society in addition to their practical function. They were frequently regarded as ritual vessels of society, displaying the ruler's status internally and maintaining political authority over a large territory (Liu, 2005; Peng, 2013; Xu, 2015). The mortuary analysis in the previous section demonstrated such a phenomenon. The top and secondary elite burials inside the Erlitou site were accompanied by drinking vessels, indicating his importance in the hierarchy differentiation; in addition, high-ranking burials in the local settlements were accompanied by the same type of drinking vessels, especially in the Yiluo region and the Jinnan region, indicating the strong influence of the Erlitou site externally. However, there is some debate about the nature of such influence (Campbell et al., 2022; Li et al., 2010; Liu and Chen, 2012).

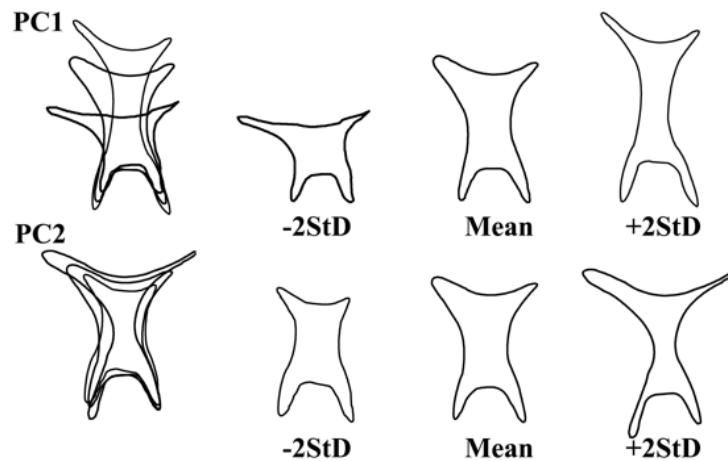
Previous research has suggested three possible models for the distribution of drinking vessels that existed over a wide area (Tokudome and Li, 2015). The first model that is most popular is the redistribution and direct control model. This model is based on the premise of a strong centralized authority with strong territorial control. The central elite tightly controlled the production of prestige pottery and redistributed it to the local chiefs. The local core sites may adhere strictly to a central-local hierarchy system (Liu and Chen, 2012). The second model was still under the strong authority of the central government, but the central power was not directly involved in the distribution of pottery as the localities were highly identified with the central rule and actively obeyed and imitated the central ritual system (Tokudome and Li, 2015). In the third model, the central influence over the localities was much weaker. Local groups received influence from the central authority but did not have a high degree of

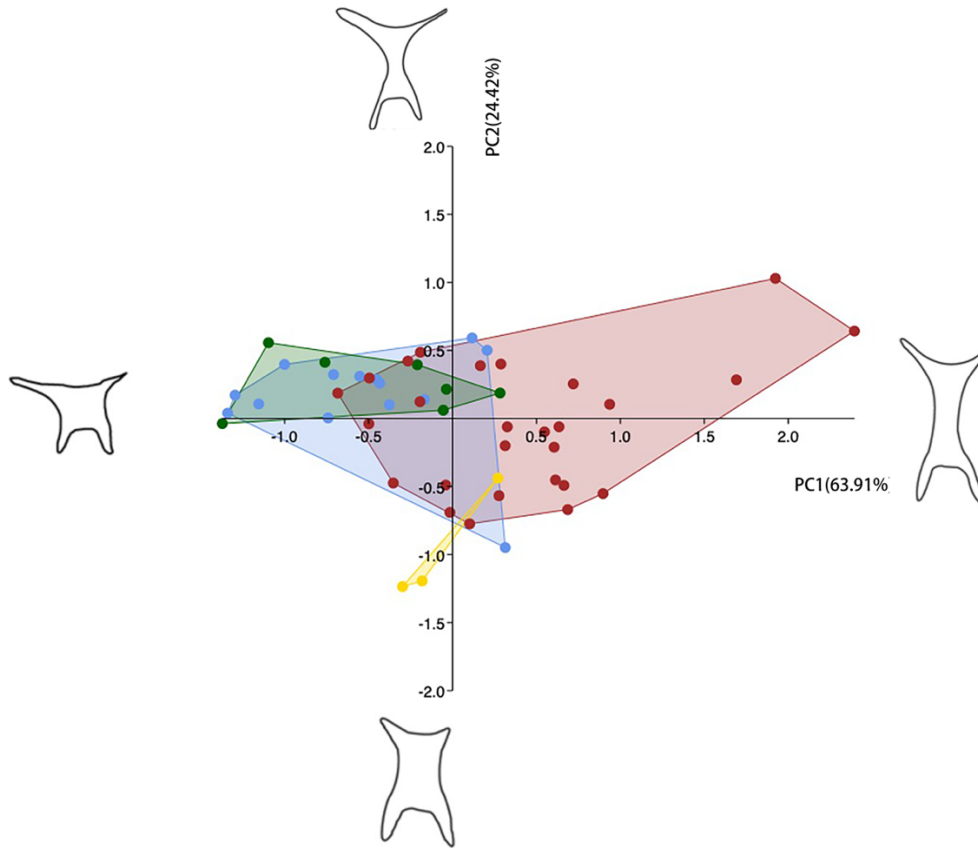
recognition or political obedience, so they may not have been directly controlled by the central authority, and the use of drinking vessels did not follow the central ritual system (Li et al., 2010).

In order to examine which model is more reasonable and to illustrate the consumption and distribution of drinking vessels in Erlitou society, this section selects samples of drinking vessels from a wide range of areas and examines their shapes and sizes in detail to investigate whether there is extreme uniformity among them, in which case they may have been consumed under central control, or significant differences, in which case they indicate a high degree of local freedom. Due to the statistical requirement for sample size mentioned before, this section selects the warm drinking vessel He and the drinking vessel Jue as the objects of study.

Jue

EFA summarized 88.34% of the total variation trends, with PC1 explaining 63.91% of the changes, mainly in Jue's height changes, and PC2 explaining 24.42% of the changes mainly about abdominal thinness.





Yellow: phase 1; red: phase 2; blue: phase 3; green: phase 4;

Figure 64 The result of EFA and PCA on morphological attributes of Jue (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The results (Figure 64) show that, in general, the degree of change of the jue also experienced a certain degree of variation. The value of PC1 is significantly greater than that of the third and fourth phases, indicating that the jue is taller in phase 2; the third phase witnesses a clear trend of standardization with a much reduced range of variation in PC1. This trend implies that the jue is becoming shorter during this time. Phase 4 continues the trend of standardization, with a much smaller range of variation than Phase 3.

Table 43 The MANOVA test result of Jue in different phases and regions

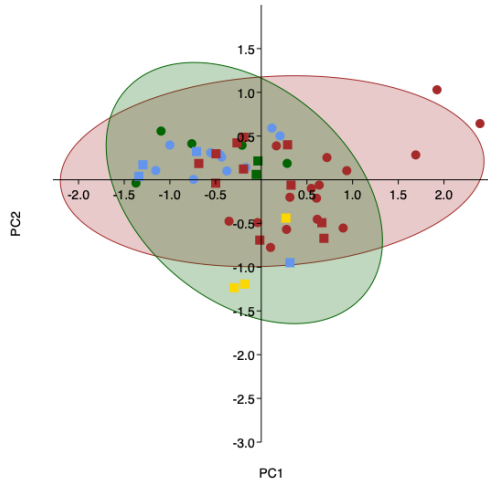
TEST	F	Error df	sig
Phase	6.712	74.000	0.000**
Center VS Local	0.786	43.000	0.508
Sub-regions	3.293	87.765	0.002*

Table 44 The ANOVA test result of PC1

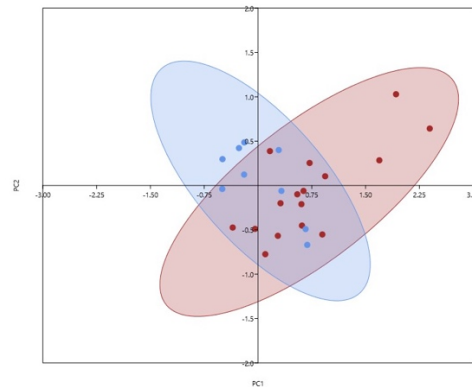
PC1	sub-regions	Sig.	sub regions	sub-regions	Sig.
Center Erlitou	J	0.043*	Yiluo Basin	C	0.326
	S	0.755		J	0.027*
	Y	0.326		S	0.305
	Z	0.053		Z	0.025*
Jinnan region	C	0.043*	Zengzhou Plain	C	0.053
	S	0.088		J	0.647
	Y	0.027*		S	0.112
	Z	0.647		Y	0.025*
Southern region	C	0.755			
	J	0.088			
	Y	0.305			
	Z	0.112			

Unlike the previous section, this section employs a comprehensive MANOVA test for PC 1 and 2, which represent shape attributes, to ensure a more precise examination of the relationship of Jue between different areas and phases. The results (Table 43) show that among these samples, there is no significant difference between the central Erlitou site samples and the local ones overall, indicating a profound influence of the central on the local Jue, which may be redistributed or highly imitated. And the results also found that there is a significant difference between different sub-regions. The ANOVA test for individual PC values can indicate exactly which of the sub-regions shows heterogeneity (Table 44). From the separate significant difference tests, we know that the Jinan region shows differences in shape with the central Erlitou site and the Yiluo region, and there are also significant differences between the Zhengzhou region and the Yiluo basin. This shows that in terms of the shape of the Jue, the Jinan region has the least similarity to the central one, indicating that the central Jue did not profoundly affect the production of the Jue in the Jinan region. At the same time, there are significant differences between the Zhengzhou plain and the Yiluo basin area,

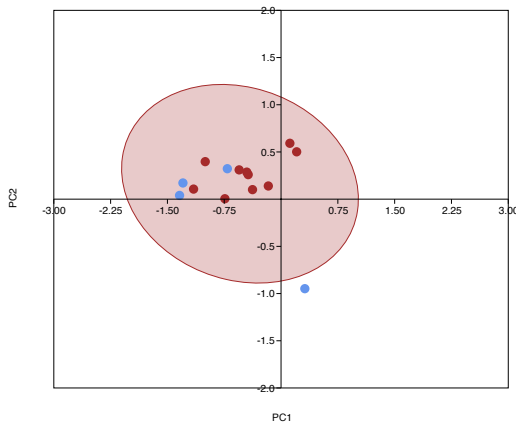
indicating that the central influence on the sub-regions was uneven, with local sub-regions having their own characteristics. Although the social significance of the Jue was recognized, it was only a rudimentary imitation, leading to the significant differences in shape in some local areas.



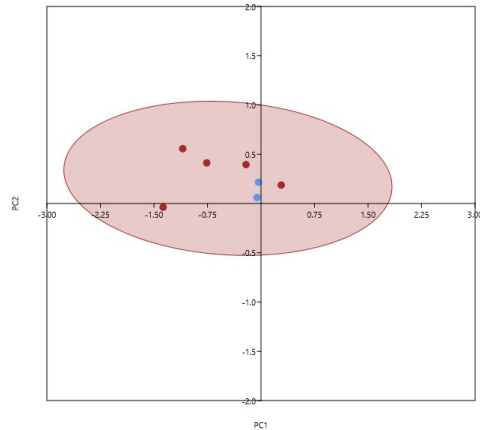
(1)



(2)



(3)



(4)

Red: Erlitou; blue: outside

Figure 65 The 95% confidence test of Jue between the core Erlitou and outside area (1) overall; (2) 2nd phase; (3) 3rd phase; (4) 4th phase

The study used a 95% confidence level test to ensure that the high variance samples within groups did not affect the comparison between groups when examining the relationship between central and local on the temporal dimension (Figure

65). Overall, there was a large overlap between the central and local samples after the 95% confidence test, representing that this part of Jue has a similar shape, but there were still some samples that were not within the overlap area.

The similarities and differences between each phase were examined in the 95% confidence level test. In phase 2, there are partial overlaps between the central samples and the local ones, but in phase 3, there is only one case out of the overall range, and this sample is from the southern regions, and in phase 4, all of them are within the central sample range. This indicates that there is some difference in shape between the central and local Jue in the second phase, and there is a gradual unification after the third phase. This gradual unification in shape indicates that the influence of the central Erlitou site gradually expanded, and the localities gradually accepted the influence of the central use of Jue and directly or indirectly obeyed the central ritual system, forming a stronger sense of common identity.

Table 45 The CV result of Jue

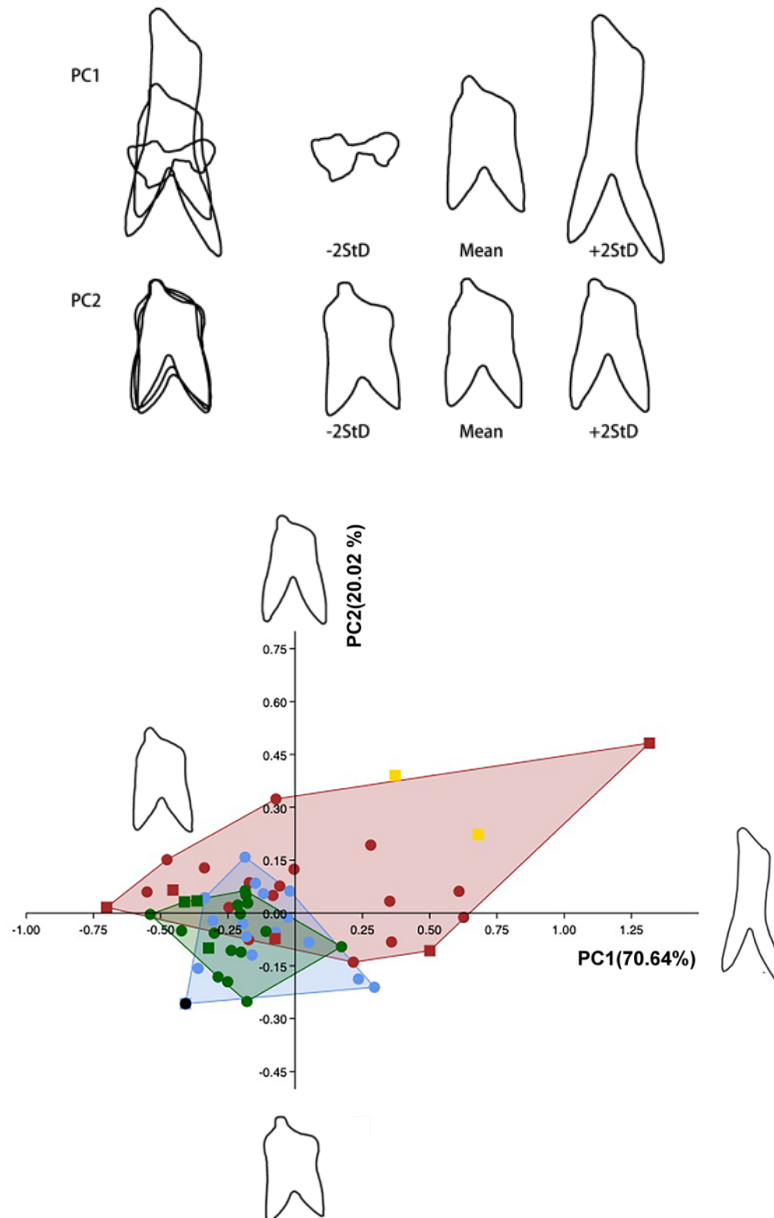
	2nd	3rd	4th
Jue(Erlitou)	13.84	6.73	5.57
Jue (outside)	19.96		8.91
He(Erlitou)	11.01	5.57	4.31
He(outside)	4.79	7.16	8.66

The CV value of Jue remained low in general (Table 45). From phase 2 and on to phases 3 and 4, CV values gradually decreased, showing a trend toward standardization. Especially after Phase 3, the CV values within the Erlitou site are 6.73 and 5.57, respectively, which are lower than those of the simultaneous cooking and storage vessels. This proves the standardized form of the jue. Meanwhile, the degree of variation is slightly greater on the exterior of Erlitou than on the interior of Erlitou.

He

He is one of the luxury warming vessels of the Erlitou culture and most of it found have fire traces on the legs, indicating its practical function.

EFA 90.67% of the total variation trends, with PC1 explaining 70.64% of the changes, mainly in Jue's height changes, and PC2 explaining 20.02 % of the changes mainly about thinness(Figure 66). First of all, a case of heteromorphic sample was found. That is, a sample with an oversized PC1 value and extremely high. In the subsequent examination, the study needed to eliminate this sample in order to avoid the impact of this variant sample in the subsequent comparison.



Yellow: phase 1; red: phase 2; blue: phase 3; green: phase 4; square: the late stage of phase 4

Figure 66 The result of EFA and PCA on morphological attributes of He (1) the shape variation implied by EFA ; (2) the PCA results of EFA

The results show that, in general, the trend of change is similar to that of Jue

(Figure 66). The second phase has a greater range of variation and significant diversity. The special sample appeared in this phase, as mentioned above. The third and fourth phases have produced a trend of standardization, and the range of change is much less, as shown by the gradually smaller range of change in PC1 and PC2 values, impeding the overall development of the He toward a short and fat form.

Table 46 The MANOVA test result of He in different phase and regions

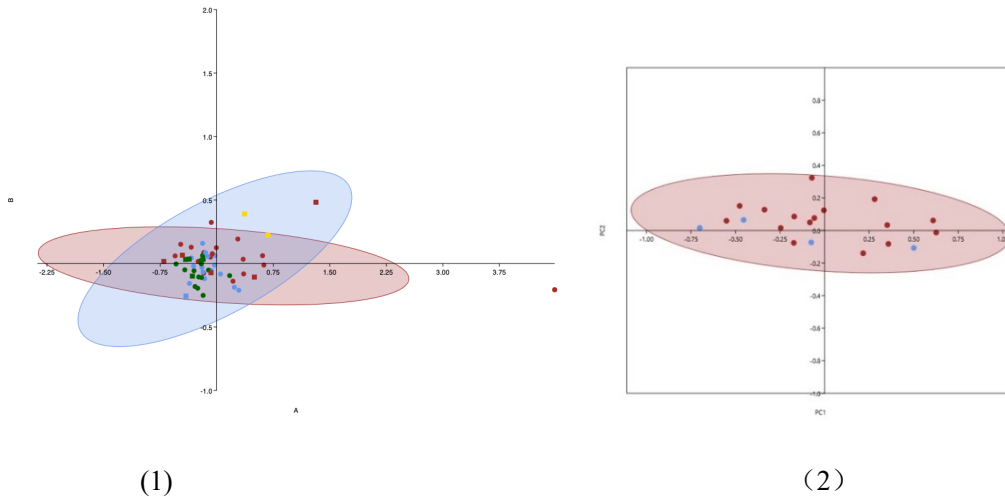
TEST	F	Error df	sig
Phase	2.578	94.000	.023*
Center VS Local	2.894	94.000	.006
Sub-regions	4.571 ^b	47.000	.003*

Table 47 The ANOVA test result of PC1

	sub-regions	Sig.		sub-regions	Sig.
Erlitou	J	0.219	Yiluo Basin	C	0.952
	S	0.012*		J	0.235
	Y	0.952		S	0.021*
	Z	0.206		Z	0.221
Jinnan region	C	0.219	Zhengzhou Plain	C	0.206
	S	0.582		J	0.978
	Y	0.235		S	0.604
	Z	0.978		Y	0.221
Southern region	C	0.012*			
	J	0.582			
	Y	0.021*			
	Z	0.604			

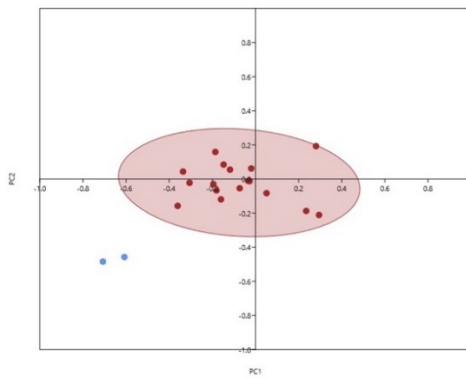
Similarly, the results of the MANOVA test for shape attributes in different temporal and spatial contexts show that there is no significant difference between the central Erlitou site sample and the local ones (Table 46), suggesting a profound influence of the central on the local He, and like Jue, there is a high degree of imitation and use of He by local groups.

The results also found that there is a significant difference between different sub-regions (Table 47). The ANOVA test for separate PC values can indicate exactly which of the sub-regions shows heterogeneity. The result of PC1 in the southern region has shown a significant difference from the central Erlitou and Yiluo basins. The samples in other regions show high similarity to the ones in the center.

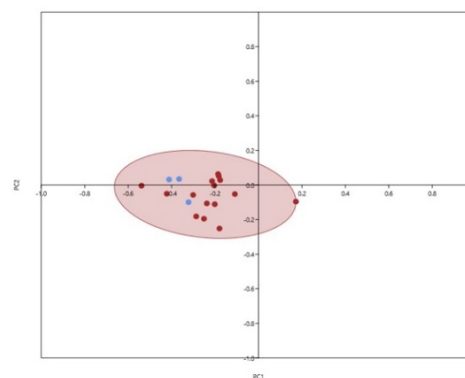


(1)

(2)



(3)



(4)

Red: Erlitou; Blue: outside

Figure 67 The 95% confidence test of Jue between the core Erlitou and outside area (1) overall; (2) 2nd phase; (3) 3rd phase; (4) 4th phase

Furthermore, the 95% confidence test has shown a slightly different result from the Jue (Figure 67). Although the variation of Jue in phase 2 is large, the local samples are all within the 95% confidence interval of the central sample, but the central samples in phase 3 show a clear trend towards standardization and the local sample has been outside of its confidence interval, indicating that there was some difference in the shape

of central and local Jue in this phase, while by phase 4 fall samples showed consistency, with all data within the confidence interval. And the overall range of variation was reduced.

The examination of dimensions also shows a high trend toward standardization. Inside the Erlitou site, there is a trend toward continuous standardization (Table 44), with CV values decreasing from Phase 2 to Phase 4, and also reaching a lower level of CV values similar to Jue. But the He outside the site shows a different trend of change. Phase 2 CV is the smallest and gradually increases afterwards, but these three phases have remained relatively standardized. Such variation also indicates that he had a certain amount of autonomy at the local groups and did not completely change with the trend of standardized changes in the center.

The use and production of drinking vessels in a wide range of regions reflect the different degrees of control and influence of the ritual system of Erlitou on the local area after the above examination of two types of drinking vessels. First, shape analysis revealed a high degree of similarity between the center Erlitou and local regions in both types of drinking vessels. There are no significant differences between the central and local regions overall, suggesting that the use of drinking vessels by the central government has profoundly influenced the nature of local drinking vessels. In particular, after the third phase, there is no difference between the entire sample of local and centralized vessels, suggesting that there may have been direct distribution by the central government or that the localities actively followed and imitated the central government's vessels after receiving dominance. This resulted in extremely similar shapes and dimensional properties. At the same time, the similarities and differences between the different phases and the range of variation in the vessels show the process of socio-political integration in the temporal dimension. From the second to the fourth phase, both types standardized and demonstrated an integration tendency.

The drinking vessels have shown differences in sub-regional tests, which indicate the local identity in some sub-regions (Table 48). The Jinnan and southern regions have shown differences from the core site. This indicates that not all samples in the sub-regions follow the central pattern, and the influence of the center is relatively limited in

the Jinnan and Southern regions. As previously stated, different distribution patterns are possible. In the Yiluo and Zhengzhou regions, the highly consistent drinking vessels indicate the strong ritual influence of the central authority. Therefore, the central Erlitou may have strong control over these regions, and there is a high level of identification with and obedience to the central government among the local groups. However, although the same type of drinking vessels have been found in the southern and Jinan regions, they differ from those of the central government and represent that they maintained their own ritual characteristics and did not receive full control from the Erlitou center. This proves that the actual ritual control was unbalanced in the so-called wide area of the Erlitou state.

Table 48 The possible relationship patterns between the center Erlitou and outside

Sub-regions	Results	Possible pattern
Y, Z	highly similar with the central drinking vessels	A.B
J, S	Difference from the central drinking vessels	C

Y:Yiluo Basin; Z:Zhengzhou Plain; J:Jinnan; S: Southern.

In summary, the investigation on different types of pottery demonstrates the various consumption of functional pottery. The shape of them shares a common feature: all the pottery examined from the first to the second phase of Erlitou witnessed a tendency to diversify and to produce a significant standardization trend after the third phase. In addition, in Phase 2, the pottery in the palace area is much more variable than in other areas, resulting in a large range of variation in the overall pottery of this phase. From phases 3 to 4, these potteries all maintain a relatively small range of variation, and the palace area becomes very standardized to a greater extent than the other areas. Then, the separate PC examinations all illustrated that there were no significant differences between the contexts. It shows that functional pottery did not produce particular differences in form due to differences in social status.

However, the standardization and differentiation shown by these goods also

produced differences according to different functions. First of all, while Dou and drinking vessels show a consistent trend toward standardization in the third and fourth phases, cooking vessels and Zun do not maintain a consistent standardization in the fourth phase but instead show a gradual increase in the range of variation, both in shape and size. As mentioned above, the variation of cooking vessels and storage vessels in phase 4 may be due to the arrival of the new population at Erlitou in the late fourth phase with new shapes for certain vessels, but the Dou and drinking vessels associated with feasting activities remained highly standardized, proving their importance in social activities, and the feasting customs and institutions of Erlitou were still preserved to some extent after the new population ruled. Finally, the degree of standardization of different types of pottery also shows differences. Drinking vessels are the most commonware in terms of shape and size dimension. Cooking and storage vessels are relatively diverse, even though the variation tends to reduce after phase 3. The actual CV is larger than that of drinking vessels.

C. The consumption and distribution of pottery

According to different uses and excavation context, the consumption behavior of Erlitou pottery can be divided into 3 categories: utilitarian pottery for elite use, unitarian pottery for commoners, and prestige pottery consumption. They exhibit distinct consumption patterns from one another.

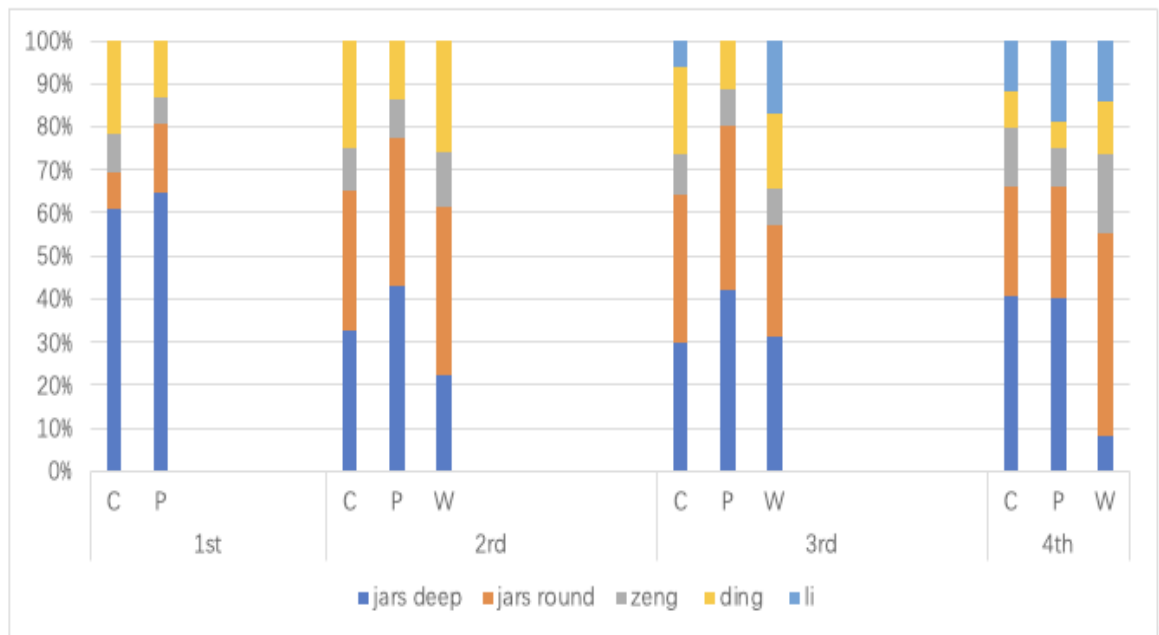
The utilitarian pottery for the elite is represented by the pottery excavated in the palace area. The consumption of drinking vessels in this context is special. They exist only in the palace area and the special craft area, and all show a high degree of standardization that is undoubtedly exclusive for elite consumption. Besides that, the other types of pottery show no difference in the common context. Then, as for the examination of the variation in shape and size, the cooking and storage vessels in the palace area in the Phase 2 area were much more diverse than they were in the commoner context, indicating the possible existence of diverse sources of vessels in this phase. Although, in this phase, so-called palace areas and large rammed earth buildings were

established, the palace area was an open area for non-noble groups, and Xie (2019) suggests that in the early stages of social integration, collective activities such as feasting were required constantly to ensure that central authority was gradually accepted and recognized, which may also explain the diversification of pottery, especially cooking vessels. Later, as the centralization of power was completed, walls were built around the palaces to isolate the elite into enclosed areas, and pottery was also standardized to varying degrees. The trend toward standardization is inextricably linked to the concentration of political power. Since the elite only needed to negotiate with the upper class of society and not with all members of society, they tended to have fixed, highly skilled pottery production units to provide them with pottery. The reduction in the number of production units and the increasing specialization of specialized workshops for hire led to increasing standardization.

The pottery found in other residential areas represents the consumption scenario of the common people. The types and compositions of pottery from these areas are utilitarian pottery with no special materials or decoration. No special pottery consumption pattern existed, and the pottery found was basically intended to meet the needs of daily life (Figure 68).

The pottery in the above two scenarios is everyday utilitarian ware; the shape ANOVA test on this pottery shows no difference between the elite and the commoner contexts, indicating that the difference in status did not affect the shape. Second, in the study of the composition of the types of cooking vessels in different scenes, it was found that although the types of cooking vessels have a proportional difference, i.e., the palace district is more inclined to utilitarian deep-bellied jars and a slightly larger proportion of tripods in other areas, there is no great difference. This suggests that there is no significant difference in the types of utilitarian vessels consumed. So the consumption pattern of the nobility in their daily lives was mainly reflected in the services of specialized workshops with a high degree of standardization, but the types (except for drinking vessels) and shapes did not differ from the commoner scene. However, such workshops were not under the strong control of the elite because the properties of ordinary pottery were not significantly different, and it is assumed that utilitarian

pottery for the elite was obtained by ordering from ordinary, stable pottery-making workshops.



C: commoner area; P: palace area; W: workshop area

Figure 68 The distribution of cooking vessels in different functional area

The third pattern of consumption is the consumption of prestige pottery. This scenario can also be further refined into two kinds of scenarios: in the context of the burial at the Erlitou site and in the scenario of the wide area outside the Erlitou site. Firstly, in the Erlitou burial context (Table 49), the top burials are marked by the most important feature of buried bronze vessels, accompanied by drinking pottery vessels and turquoise and jade vessels. An examination of the burial assemblage at the Erlitou site reveals that pottery and ritual objects are not only found in the top elite burials but also in the secondary and third-ranked burials. Higher-level burials typically include the entire set of drinking ware, a combination of warming ware and drinking ware: the combination of He and Jue, whereas lower-level burials typically include Gu in place of the drinking ware Jue. Because of the invention of bronze Jue after the third phase, pottery Jue tended to suffer a certain downgrade, appearing primarily in secondary noble burials. Thus, it can be seen that bronze and pottery shared the function of indicating elite status in Erlitou burials. Moreover, in the examination of the degree of standardization in general, the overall degree of standardization of prestige pottery is

high, but the level of standardization does not correspond to the rank of burials. The consumption and distribution of drinking in the Erlitou society in the wide area has been examined above, and it has been shaped to be followed by local settlement centers, especially in Yiluo Basin area.

Table 49 The burial assemblage of different ranked burials

Erlitou	1 st rank			2 nd rank		3 rd rank
	Pottery drinking vessels	Bronze items	Jade types(max)	Pottery vessels	drinking	Pottery drinking vessels
1 st				Gu		Gu
2 rd				Jue/jue/gu/gui		Jue+Gu
early						
2 rd late	He+(jue)	Ling	2	He+jue(70%)/gu(30%)		Gu
3 st	He+jue	Jue	2	He+jue		
early		+Ling(pad)				
3 st late	He	Jue	3	He+jue		
		+weapon(pad)				
4 th	He	Jue	3	He		Gu/ he
early						
4 th late	He	Jue +Ling	5			Gu

The consumption patterns in the above three different scenarios illustrate that Erlitou society shows more complex production and consumption mechanisms compared to Taosi society. Although the two basic motives for consumption—market and elite intervention—were present in Erlitou and society as well, the motives for the consumption and distribution of different pottery were more complex in the face of a more complex social system.

The geographical distance of the exchange range of this pottery has extended far beyond the Erlitou center itself. It is possible that the utilitarian wares within the site, whether used in the commoner area or by the elite in the palace area, depended on production workshops at the edge of the site or even in the adjacent rural areas. But such workshops did not show the characteristics of being strictly controlled by the central elite but continued to produce independently, importing their products to the center through exchange or possibly trade. On the other hand, prestige pottery was obtained from specific production units, and its use and distribution came under the

control of the central specialized management section. In particular, the white pottery drinking vessels mentioned above may have been obtained from more distant regions.

To further understand this long-distance pattern of exchange and production, white pottery is explored further in the next section.

5.3.3 The white pottery in Erlitou culture

White pottery is a special type of pottery made of kaolin clay and fired at a high temperature. Since white pottery is only found in palace areas and high-ranking burials at the Erlitou site, researchers believe that white pottery was a high-specification pottery prestige vessel of Erlitou society, with a special source and distribution system (He, 2022; Liu and Chen, 2012; Nishie and Kuji, 2009; Xu, 2015). Some scholars believe that the production and distribution of white pottery was under the centralized control of the elite, was an attached production practice like bronze production, and symbolized the ritual system of Erlitou distributed to local groups (Liu and Chen, 2012). However, in recent years, with the innovation of scientific methods such as raw material analysis and examination in a broader spatial and temporal context, it has been argued that the control and production of white pottery did not show a centralized trend but rather that there was mutual exchange between local groups (Li et al., 2010). Therefore, it is necessary to reassess the production system of white pottery at Erlitou.

At present, white pottery has been found mainly in the Yiluo basin, southern Henan (sites include Yanshi Erlitou, Ashizui, Dongmagou, Shorty Li, Soapjiao Shu, Donggangou, Yucun, Xingyang Nyangzhai, Xindi Xintai, Yuzhou Dongzhuang, Pingdingshan Xiaodian, Ruzhoushan, Haojiatai, Mianchi Lusi, Zheng Yao, and Xiyacun in Shaanxi). (Figure 69) (He, 2022) The main types of wares found are drinking vessels, storage vessels, and some tools, covering the first to fourth phases of the Erlitou culture, but mainly concentrated in the first and second phases, with only scattered specimens from the third and fourth phases (Zhongguo, 2014).

The white drinking vessels are the prestige pottery and even more precious than the ordinary drinking pottery, so combined with the results of the above examination of

Jue and He, this section selects white ones for examination of shape and size, discusses the characteristics of consumption and distribution of white drinking vessels in a wide area, and finally speculates on the possible production system of white drinking vessels.

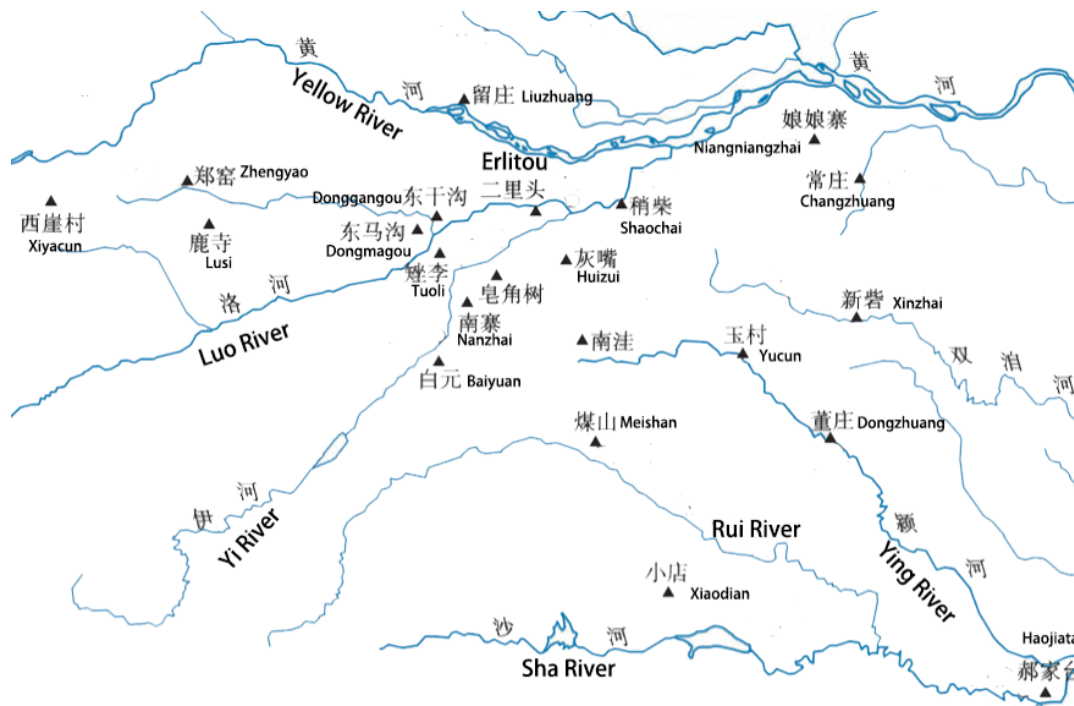


Figure 69 The location of settlements where found white pottery (He, 2022)

5.3.3.1 Raw material

The XFR results have shown that the raw material of white pottery is significantly different from ordinary pottery, as mentioned above. The Li et al. study (2010) provided the opportunity to further investigate the detailed raw material of white pottery by publishing fingerprint chemical component data for a batch of white pottery. In this study, LDA was used to examine the details of trace elements of white pottery excavated from different sites. Higher LDA group scores demonstrated a higher degree of similarity between the two groups.

The results show that Erlitou and Nanwa show the highest similarity, while Huizui and Nanzhai show some degree of individuality (Table 50). Firstly, the samples excavated from each site itself have the highest similarity with a coefficient above 10, and secondly, the higher degree of mutual similarity between the two groups of Nanwa and Erlitou indicates a high degree of similarity in the raw materials of white pottery,

and the samples from Huizui also show similarity to those from Nanwa and Erlitou, indicating that there may be a consistency in the raw materials. The white pottery from Nanzhai, on the other hand, shows an independent origin with little similarity with other sites. The above results show that there was a clear circulation of white pottery in the wide area of Erlitou, which may have had the same source as well as separate production sources.

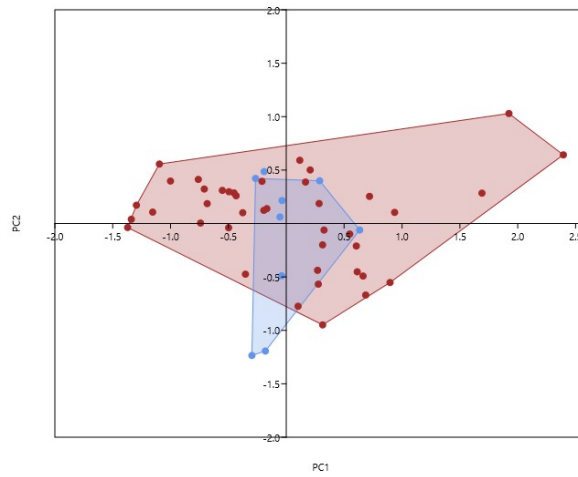
Table 50 The LDA result of white pottery in different sites

	Nanwa	Erlitou	Huizui	Nanzhai	Soil from Nanwa
Nanwa	11	3	0	0	0
Erlitou	5	11	6	1	0
Huizui	2	4	5	0	0
Nanzhai	0	0	0	2	0
Soil from Nanwa	0	0	0	0	2

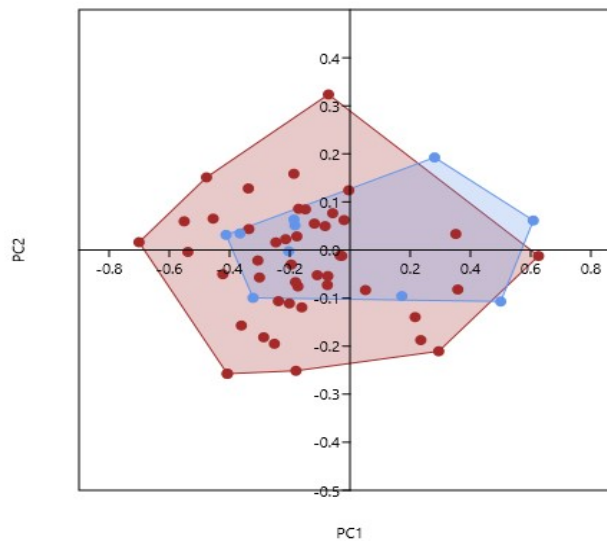
5.3.3.2 Shape and size measurement

Combining the above studies of the morphology and dimensional variation of the two types of vessels, this section compares white drinking vessels with non-white ones. The results of the EFA (Figure 70) show that white vessels show a small trend of variation in both He and Jue and that most of the samples are overlapped with vessels of other materials. The MANOVA test also showed no significant difference between white drinking pottery and non-white ones (Table 51). This indicates that the white vessels are derived from the ordinary drinking vessels but are much more standardized. It is worth noting that the samples outside the overlap area all come from sites outside Erlitou, whereas the two samples of Jue and the two samples of He are from the Nanzhai site in Phase 1. In Phase 1, there is no clear, complete sample of white pottery found in Erlitou, which may allude to the cultural genealogy of white pottery in Jue and He,

which gradually developed from Nanzhai. And of course, more evidence is needed for this assumption. After the exclusion of these four samples, all the white pottery samples fall within the variation of non-white pottery wine vessels. This reinforces the fact that white pottery drinking vessels do not exist in a special form but are dependent on the shape of ordinary drinking vessels that possess a more standardized shape.



(1)



(2)

Figure 70 The comparison of drinking vessels between white one and non-white one(1)He;(2)Jue (Red:non-white one ; blue: white one)

Table 51 The result of MAVOVA test between white and non-white drinking vessels

TEST	F	Error df	sig
Jue	.428 ^b	43.000	.734
He	1.535	104.000	.174

White pottery vessels also show a high degree of standardization in terms of size. The comparison between white and non-white vessels of the same type shows that the CVs of the Gui and Jue are smaller than those of the non-white ones, both in the overall Erlitou phases and in the Erlitou 2nd phase (Table 52), when the peak of white pottery use, suggesting a greater standardization of dimensions of white pottery. In addition, the CV of white He is slightly larger in overall phases, probably due to interference caused by the long time span (Blackman et al., 1993), while the CV of samples from 4th phase also shows a greater standardization of white He than the non-white ones. Therefore, white pottery shows a higher degree of standardization both in shape and size than the non-white pottery of the same type.

Table 52 The result of CV comparisons of white and non-white drinking vessels

	TOTAL		2 nd phase	
	White	Non-white	White	Non-white
GUI	5.59	12.25	5.59	13.40
JUE	9.11	14.57	9.11	15.08
HE	10.00	8.28	*	10.60
		(4 th phase)	2.19	4.82

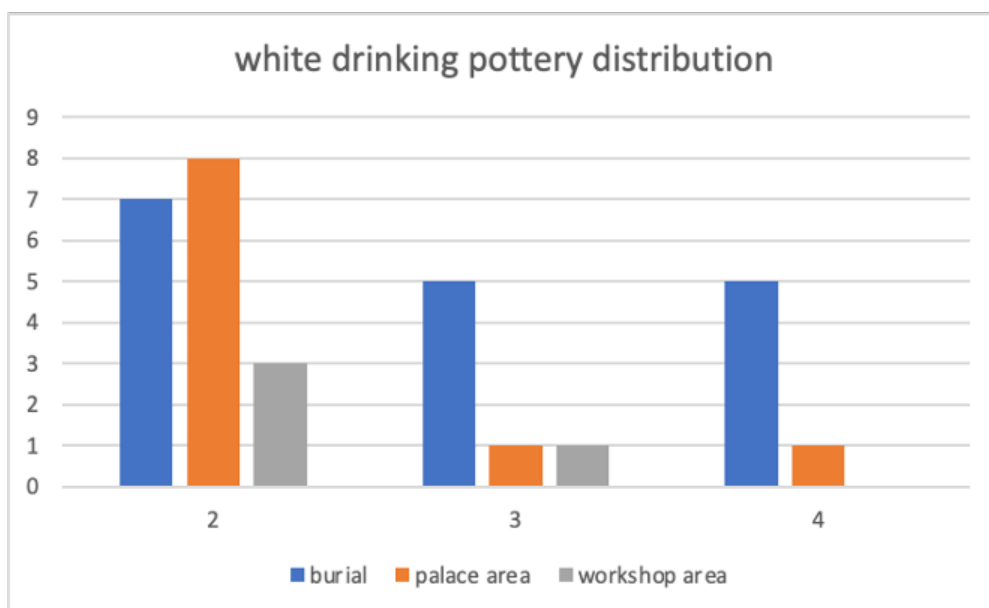
*The sample size is too small(He with fully size descriptions), so the research also calculate the sample from the 4th phase to make a comparison

* The unusual samples were discovered during the study of the He. The overall body of these three samples were exceptionally elongated, with huge dimensions, and the handles are segmented, distinguishing them from the other ones. These samples were over 30 cm in height and also showed abnormal values for PC1 in the shape study and were not included in the shape analysis before. In the calculation of size CV, three cases of huge size samples were also not included in the calculation to avoid errors in the standardized results (Underhill, 2002). The samples are 2001-VM1:7; 2001-VM1:17; IVM18:7.

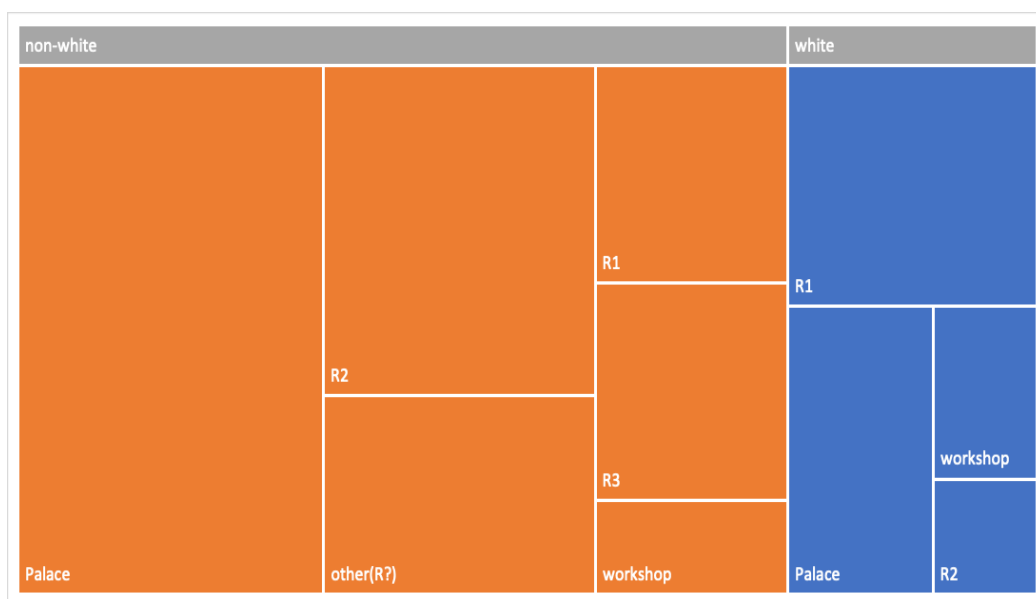
5.3.3.3 Consumption and distribution pattern

The consumption of white pottery was highly specific and exclusive to the elite group. Within Erlitou site, currently white vessels are distributed in three main contexts, the palace area, high-ranking burials and the luxury craft workshop area. Among the

burials, the white drinking pottery is mainly distributed in the top and secondary tombs in phase 2, usually accompanied by jade and bronze items, and after Phase 3 it only appears among the top tombs, indicating consumers of such white pottery were the top elite group of Erlitou. While in the palace area, the white pottery found in the phase 2 is the most and when it came to the phase 3, the white pottery in palace area is much fewer than it in burials, indicating the gradual withdrawal of white pottery from the utilitarian context from this phase. Furthermore, the emergence of bronze drinking vessel had a significant impact on the consumption of white pottery and the whole ritual system. Along with the emergence of bronze Jue, the overall number of white pottery drinking vessels was greatly reduced after phase 3 (Miyamoto, 2005), and the bronze vessels gradually took the place of white pottery in the top tombs in terms of the burial assemblage. In addition, a small amount of white pottery was also found in the workshop area, mainly for turquoise production, which was located in the middle of the palace area and the bronze workshop area, surrounded by walls, and was a centralized production area under the control of the elite (Zhao, 2020). The discovery of white pottery drinking vessels in this area indicates the importance of turquoise production and the relatively high social status of the practitioners or supervisors (Figure 71:1).



(1)



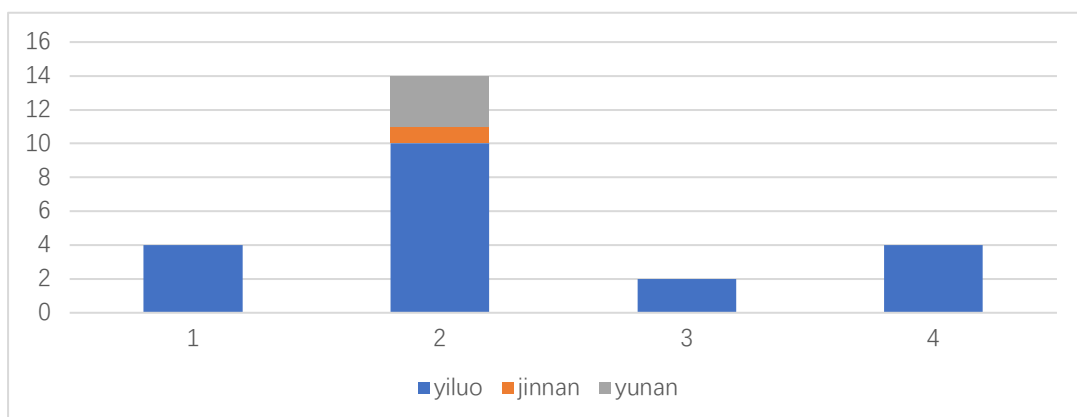
(2)

Figure 71 White drinking pottery distribution in the Erlitou

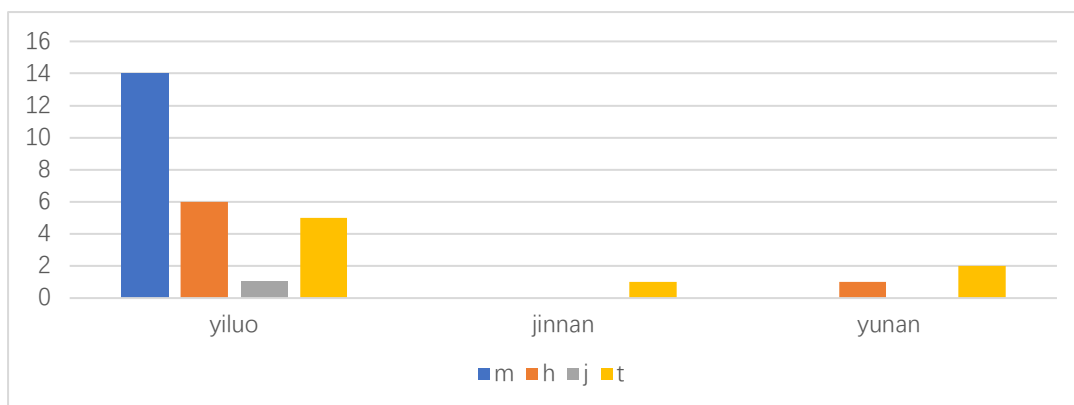
In addition to its relatively high social status as suggested by the change in the use of white pottery over time, white pottery also shows the characteristics of serving the top elite compared to non-white pottery of the same type, especially in the phase 2. The Table 52 and Figure 71(2) shows the distribution of drinking pottery in different context that can imply the consumption patterns of different drinking vessels in the phase 2. It is obvious that the majority to white pottery was consumed in the top elite burials (Rank 1 burials). Then the palace elite also possessed the eligibility to use white drinking vessels, and only a small amount of white ones was found among the second-ranking elite burials and in craft workshops. On the other hand, non-white vessels, however, are more often found in secondary elite burials and in practical use by palace elite. Top elite burials were less often consumed the non-white ones. And 3rd ranked elite burials were also occasionally buried with them. Such consumption patterns in different ranked scenarios clearly indicate that the consumption of white pottery was more the right of the top elite than non-white wares. Therefore, white drinking vessels had the most important social role and significance at least in phase 2, symbolizing the highest power and status of the top elite .

On a wider area outside the Erlitou site, there are 194 pieces of white pottery, all of which are non-wine vessels from the pits of the Nanwa site (Han and Zhang, 2014),

while all other samples of white pottery found elsewhere are drinking vessels (Figure 69). It has been proven in previous studies that Nanwa was a large production base of white pottery, mainly exporting white pottery drinking vessels but not using it itself (Han and Zhang, 2014), so the statistics of external consumption do not include samples from the Nanwa site. The white drinking vessels are mainly concentrated in the Yiluo area, with a smaller number found in Jinan and southern Henan. There is no sample in the Zhengzhou area. In terms of temporal changes, phase 2 has the most white pottery, and the number drops dramatically in phases 3 and 4. Such a tendency is consistent with the change in Erlitou. This indicates that the changes to the ritual system at the Erlitou site also had a direct impact on its wide distribution and consumption patterns. Besides that, the different regions also show different patterns of consumption. The white pottery is found in both burial and practical contexts, and the Yiluo area shows a similar pattern (Figure 72). In the other two regions, however, white pottery is not found in burials but only in non-burial contexts. This indicates that the traditional burial rituals and consumption patterns in southern Jin and the surrounding area differ from those in the Erlitou Center and the Yiluo Basin. These sites with white pottery excavated are geographically distributed in the border areas; for example, the Xiyacun site is located in the southern border area of the Erlitou society (Figure 69). Therefore, these border sites may get white pottery due to a political purpose, and these white pieces are distributed to symbolize the control and influence of the Erlitou Center in this area.



(1)



(2)

M:burials; H:pits; J: well; T: others

Figure 72 The distribution of white pottery in different area and types of contexts

In summary, it is clear that the production, consumption, and distribution of white drinking vessels received a large degree of elite intervention. The highly standardized forms shown by white pottery indicate that their shapes received a high degree of control and demand, being required to be extremely similar in shape under the premise of representing the status of the elite, and that their production was also very technically advanced, in terms of obtaining scarce kaolin raw materials, mastering high-temperature firing techniques, and highly standardized forming. Such production features imply a high degree of specialization driven by the elite agency.

From the analysis of the tracing factors of the clay, Nanwa shows the closest relationship with the white pottery of Erlitou Center, and the same raw materials as Nanwa white pottery have been found in other sites, so these white potteries are probably the products of the Nanwa site. Therefore, there were highly specialized production workshops at Nanwa dedicated to the production of white pottery(Figure 73). More evidence is needed to prove whether the workshop at Nanwa was under the direct control of the Erlitou regime or not. However, it is undeniable that even without direct involvement in production, the central elite of Erlitou had a strong influence on the production of white pottery, and the high demand and uniform standards for prestige items contribute to the high specialization of white pottery production at the Nanwa site. The elite in the center can acquire the white pottery from a fixed professional production organization and redistribute it to the local site, which also requires supervision and enforcement by specialized managers. In this situation, the

specialization of the white pottery production also implies a further strengthened division within the elite group, with specialized management institutions.

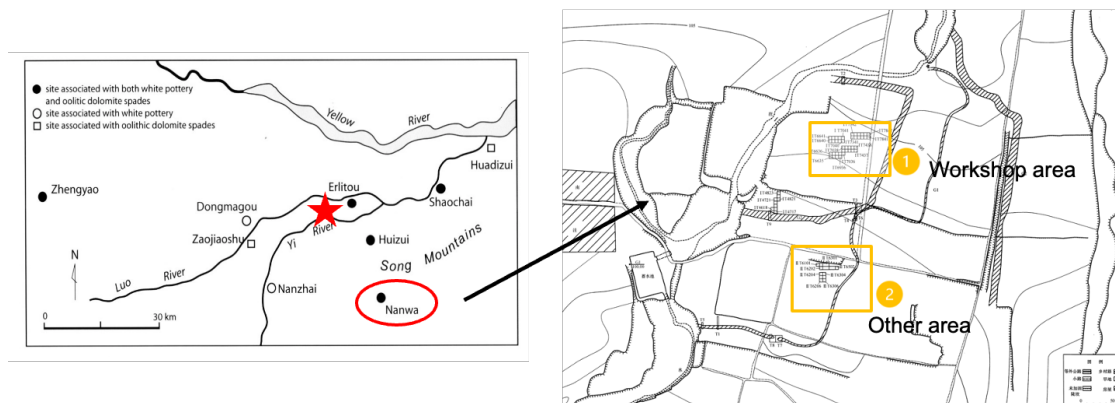


Figure 73 The location and settlement pattern of Nanwa

Furthermore, in terms of consumption and distribution, the Erlitou site was internally supplied with white pottery, primarily for consumption and funerary practice by the top elite. The similarity of the consumption and distribution patterns in the Yiluo area suggests that they shared a common ritual and ideological system and received direct control from the central Erlitou authority. The other regions did not fully comply with the white pottery consumption pattern, and although they may have been influenced by the Erlitou center, the degree is far less than in the Yiluo region. In other words, the Yiluo Basin was the core area of political and cultural influence of Erlitou culture in Erlitou wide society, at least in the early stages of Erlitou. The ceramic prestige vessels represented by white drinking vessels only have external influence in phase 2. After the third phase, the effect was greatly reduced. The reason for this may be complex. First, after the third phase, the status of white pottery as a prestige good was gradually replaced by bronze vessels and jade, which no longer had the function of sustaining political integration. Secondly, after the third phase, the political domination of Erlitou was at its peak, and internal social stability and external control reached an unprecedented level, lasting until the early part of the fourth phase, when the process of external political integration of Erlitou culture was complete and there was no need for pottery ritual wares as a tool to maintain domination, so white pottery gradually did not appear in areas other than Erlitou.

Therefore, as one of the important components of the Erlitou ritual system, the

production and distribution of white pottery received profound influence from the central elite. It was produced in a highly specialized production organization, acquired and distributed through a specialized management group, and represented the ritual system and political strategy of the early Erlitou period. After the completion of the integration of a wide area of Erlitou society, white pottery gradually withdrew from the ritual system until its eventual disappearance due to the change in external control and the status of ritual ware.

5.3.4 The pottery production and specialization in Erlitou Culture

The pottery production system of the Erlitou society was more complex than that of the Taosi society. It contains a more complex relationship between production components and a substantial separation of production institutions(Figure 75). First of all, as for the producer components, the study speculates that some of the potters were specialized artisans. In particular, the production units for making white pottery had a centralized and larger-scale production space, and the consistency of the rise and fall of the Nanwa site and the increase and decrease in the consumption of white pottery at the Erlitou site mentioned implies that the main function of Nanwa was the production of pottery for Erlitou and the surrounding area. Apart from basic household utensils and a small number of agricultural tools, no obvious evidence of other craft production was found at the Nanwa site (Han and Zhang, 2014). It is therefore assumed that large-scale workshops specializing in the production of white pottery existed at the Nanwa site, especially in Erlitou phase 2 (the peak of white pottery use)(He, 2022), and that the artisans at Nanwa were probably specialized potters(Figure 73, 74). Secondly, Nanwa is located geographically far from the Erlitou site, and the fixed and continuous acquisition of white pottery required specialized managers, so the production and consumption of white pottery also contributed to the creation of a specialized craft management group. In addition, although information on the pottery workshops within the Erlitou site is lacking, information on the producers within the Erlitou site can be inferred from the differences in pottery types and shapes. A group of professional

potters had formed at the edge of Erlitou to provide daily consumption for the entire Erlitou site, especially for the elite. Faced with a large population's demand for pottery, the increased standardization met all of the indicators of the mechanical standardization model mentioned in Chapter 2, indicating a deepening specialization level of their production. Moreover, by examining the standardization of shapes and sizes of pottery such as daily cooking vessels and storage vessels, we know that the degree of standardization of these potteries showed a high degree of consistency with the concentration of rights in the palace area, which may indicate that they came from specific workshops with a high degree of specialization. Thus, the specialized identity of potters may have increased during the Erlitou period. However, since information on specific pottery workshops has not been published, it is impossible to determine whether they are full-time or not. Then, while there is no clear evidence of the potters' social identity, the withdrawal of pottery production units from Erlitou's core area already indicates their low status. In the Taosi society, although the production units were located in the household area, they were closer to the core functional area of Taosi and the elite residential area. But in the Erlitou area, the core areas found so far include the ritual area, the bronze and turquoise workshop area, the palace area, and the elite residential area, and no clear pottery production remains have been found, indicating that pottery production has given way to these important functional areas. It is possible that the pottery production was located on the northwestern edge of the city or even in the countryside. (The latest newsletters claim to have found a large-scale pottery workshop on the northwestern edge of the Erlitou site, containing a large amount of pottery equipment, remains, and other remains, but no specific data have been published.) Such an act of giving way may indicate that pottery production did not receive the same attention as other crafts, and the marginal location also represents a relatively lower social status for potters than for bronze artisans.

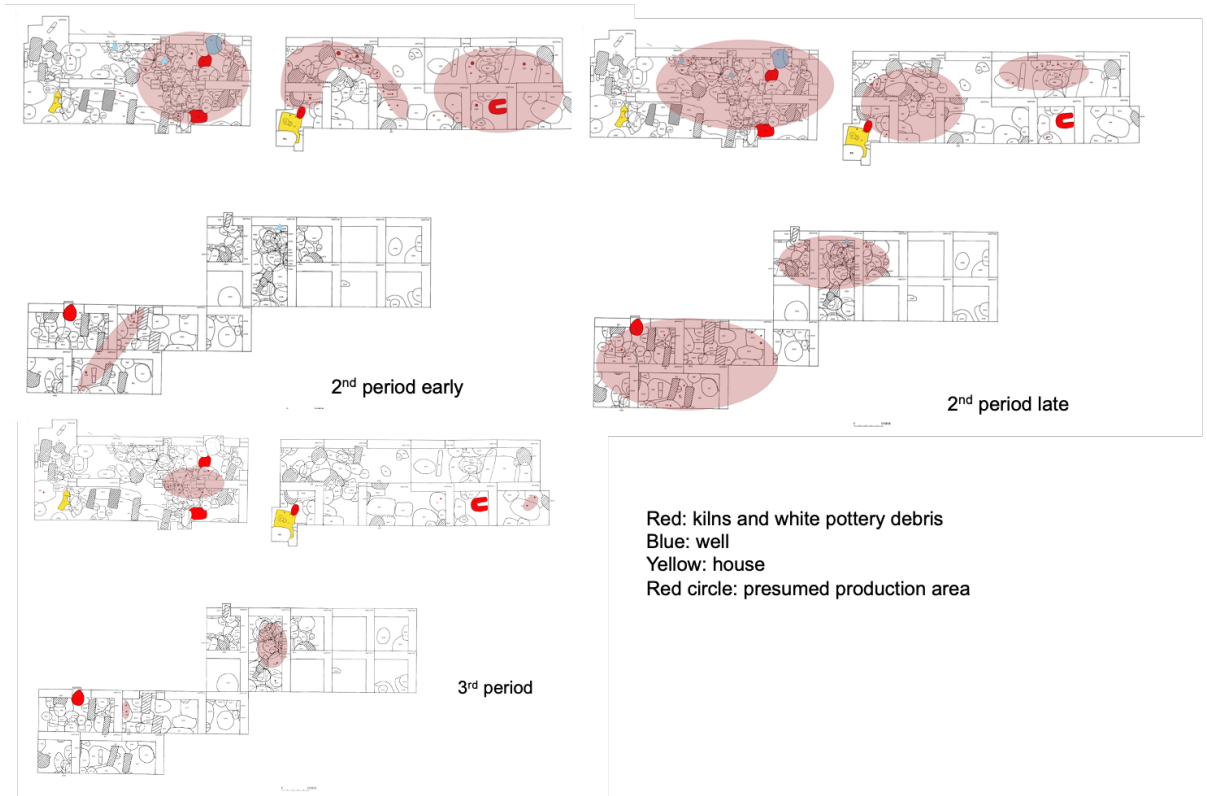


Figure 74 The kilns and debris distribution of white pottery production in Nanwa

In terms of means of production. The raw materials for ordinary and special pottery are distinctive. Among them, special pottery is mainly white pottery and primitive porcelain. The raw material for white pottery is kaolin clay, which is widely distributed in Gongyi, Nanwa, and other areas but is not easily accessible due to its distance from the main consumption areas: the Erlitou site. Compared to the special pottery, there is no special source for the clay of utilitarian pottery, which was obtained around the Erlitou site. The technology of pottery production is polarized between the ordinary pottery and white pottery. The level of production of ordinary pottery at Erlitou is thought to have suffered a sudden decline compared to previous eras. In the Longshan culture stage in the north and south of the Songshan area, the overall level of pottery production technology was high, with regular shapes and even colors for everyday utilitarian pottery. However, since the early Erlitou culture, the production technology of pottery has declined, the pottery has thickened, the proportion of hand-made pottery has increased, and the shape of the pottery has been adjusted to be less regular. On the contrary, however, the production of prestige pottery, especially white pottery drinking ware, was highly skilled, with precious materials, high firing temperatures, and a

regular and uniform appearance. In organizational principle, white pottery production units had a centralized production space, located in a dedicated production area, separated from the burial and living areas (Figure 73). The concentrated distribution of multiple kilns also attests to the large scale and high intensity of production activities at the Nanwa site (Figure 74). Socially, there is no evidence as to whether they came from the same family or group at Nanwa. However, the main function of the site is to produce pottery, and there is social stratification at Nanwa itself. The burial M2 shows his honored status with drinking pottery, shells, and other burial objects, but the others are small burials with fewer burial objects, so the social status of the potters is not high.

The different functions and social meanings of the products themselves became more complex, and their production materials and variations in size and shape showed a variety of results. In addition to their practical function, pottery drinking vessels had a special social symbolism, so their shape was regular and their quality was high. Although they had a complex production process, they were more standardized in shape and size than ordinary pottery, and the white pottery material was more standardized, indicating that they were continuously subject to strict control and requirements from the elite. Ordinary pottery also underwent a change in standardization during the Erlitou period, but not as much as the prestige kind.

The exchange and distribution patterns are also more complex. The range of exchanged pottery extended far beyond the Erlitou center itself. First of all, it is possible that the internal utilitarian wares of the site, whether used in the general area or in the palace district, were from production workshops at the edge of the site or even in the adjacent rural areas. Such workshops did not show the characteristics of being controlled by the elite but continued to produce independently, importing their products to the center through exchange or trade without showing any obvious inequality in exchange relations. In addition, previous studies have shown that there was no cross-regional exchange of general pottery in the Liluo Valley region of the Erlitou culture (Bonomo, 2018), which means that general pottery was produced and sold by each settlement on its own. Prestige pottery, on the other hand, was obtained from specific production units, and its use and distribution received the control of a central

specialized management. In particular, the white drinking vessels mentioned above were probably obtained from the more distant Nanwa area (He, 2022). Highly specialized production workshops specializing in white pottery existed in Nanwa. Whether or not the production workshops at Nanwa received direct control from the Erlitou regime currently requires more evidence to support it. However, it is undeniable that even without direct involvement in production, the central elite of Erlitou had an influence on the production of white pottery. The high demand and uniform standards for prestige wares made the specialization of Nanwa production much greater than other types of production, and the acquisition of white pottery from a fixed professional production organization and its redistribution, which also required supervision and enforcement by a dedicated manager, increased the specialization of the craft production and the internal control of the management. The specialization of the craft industry and the internal division of management were further strengthened. Furthermore, the discovery of drinking vessels outside of the site, particularly white pottery vessels at distant sites, represents a political and ritualistic external influence on the larger territory, implying an unequal relationship in such exchange and distribution. Liu et al. (2000) point out that such an unequal exchange relationship is not absolute and that white pottery was also exchanged in small portions between sub-settlement centers and was not directly distributed by the Erlitou elite. Thus, there is a combination of redistribution and free exchange in the distribution of prestige pottery.

As for the consumption patterns, they are analyzed and summarized in detail in Chapter 5. According to the different consumption contexts, the consumption patterns are divided into those of utilitarian and prestige pottery texts, the consumption patterns are divided into those of utilitarian and prestige pottery. In the case of utilitarian wares, the types of consumption do not differ significantly from one region to another, and the types (except for drinking vessels) and shapes do not differ between elite and non-elite scenes. In addition, prestige pottery is found in both burial and living contexts in extensive areas. White pottery is not only found in the top elite burials but also in secondary elite burials. And the higher-level burials tend to be buried with the whole set of drinking ware, a combination of warm wine ware and drinking ware (the

combination of He and Jue), while the lower-ranked burials tend to use Gu to replace the drinking ware Jue. Due to the invention of bronze Jue after the third phase, the pottery Jue produced a certain downgrade, primarily appearing in secondary elite burials (Table 50). Thus, it can be seen that bronze and pottery items shared the role of ritual vessels in Erlitou burials. The white pottery of Erlitou society was undoubtedly a symbol of central power. It has been found and followed by local settlement centers, especially in the Yiluo Basin. But this situation only lasted until the Erlitou phase 3.

The consumption patterns in the above three different scenarios illustrate that Erlitou society shows a more complex production and consumption mechanism compared to Taosi society. Although the basic two motives for consumption—market and elite intervention—were also present in Erlitou society, the production systems and production relations for different pottery were more complex in the face of a more complex social system.

It is important to note that the production system of prestige pottery, especially white pottery, at Erlitou did not form a full-time attached production system under central control, as expected, and did not form an absolutely strict system of tribute and redistribution. In previous studies of craft production in Erlitou society, most researchers such as Liu and Chen (2012), Liu (2005) and Pei (2019) have argued that in early Chinese states, the states exerted the strongest control over all strategic components of production. Bronze, turquoise, and white pottery, in particular, are frequently thought to have been produced under central control (Qin, 2022). Because of this monopoly, the royal power in the Central Plains was founded on complete control over production-related components such as resource extraction, distribution, production, and consumption. However, the white pottery production system examined in this paper does not conform to such a model. Compared to bronze and turquoise production, white pottery production had its own distinctive characteristics. Unlike the bronze and turquoise workshops, which were located near the palace, white pottery was imported from outside the site and obtained at the distant Nanwa site. There is no strong evidence that the Nanwa site was under the direct control of the Erlitou elite, and no relevant governing institutions have been found in Nanwa. The relationship between

Nanwa and the Erlitou center therefore requires further reflection, but the previous argument of attached production is not convincing.

Then the exchange section has more complexity than the previous argument that there is a redistribution system for prestige craft items. In addition to the possible existence of other state-controlled tribute and distribution systems in state societies, two other possible models of political economy are considered to exist: resource absorption systems and entrepreneurial systems. Spence et al. (1984) devise a model, which Bloxam (2003: 160, 2006) deduces as "resource absorption," in which states were more interested in securing the procurement networks rather than the resources themselves. Under the concept of resource absorption, state intervention existed, but it did not dominate all aspects of production (Spence 1981). Under this system, there are a series of intermediaries to coordinate the relationship between resources, artisans, and state institutions. Such intermediaries are more like representatives of the state.

Another model is the so-called entrepreneurial model, which is a more free market model. Such a system has its own channels of exchange as well as a production network. In such a system, the production and exchange of goods are essentially not controlled by political power but serve the elite's economic interests. Based on such considerations, the production of prestige pottery may have more possibilities in production machines and systems. Then the Nanwa site was established as a white pottery production base with the advantage of resources and technology to provide white pottery products to Erlitou society. Because of the special status of white pottery at Erlitou, as well as its concentrated presence in the center and the small amount that has always been present in the vicinity, although a small amount may exist in other areas for a small number of transactions, it shows that the center of Erlitou was the main center of consumption, indicating that white pottery was not traded and exchanged like a general commodity. The exchange and production are directional and uneven. The center of Erlitou importantly influenced the production of white pottery. Necessarily, it was subject to some degree of elite involvement. Then the specialized acquisition and distribution management group mentioned above assumed the role of intermediaries, forming a similar pattern of resource acquisition. In contrast, the general drinking ware and the

Elite daily ware are more of an entrepreneurial model. It did not receive a special management agency and was imported directly from workshops in the urban periphery, which did not require special long-distance transportation and management compared to white pottery. Therefore, the production and exchange system in a political economy context is more complex than the previous model and contains multiple forms.

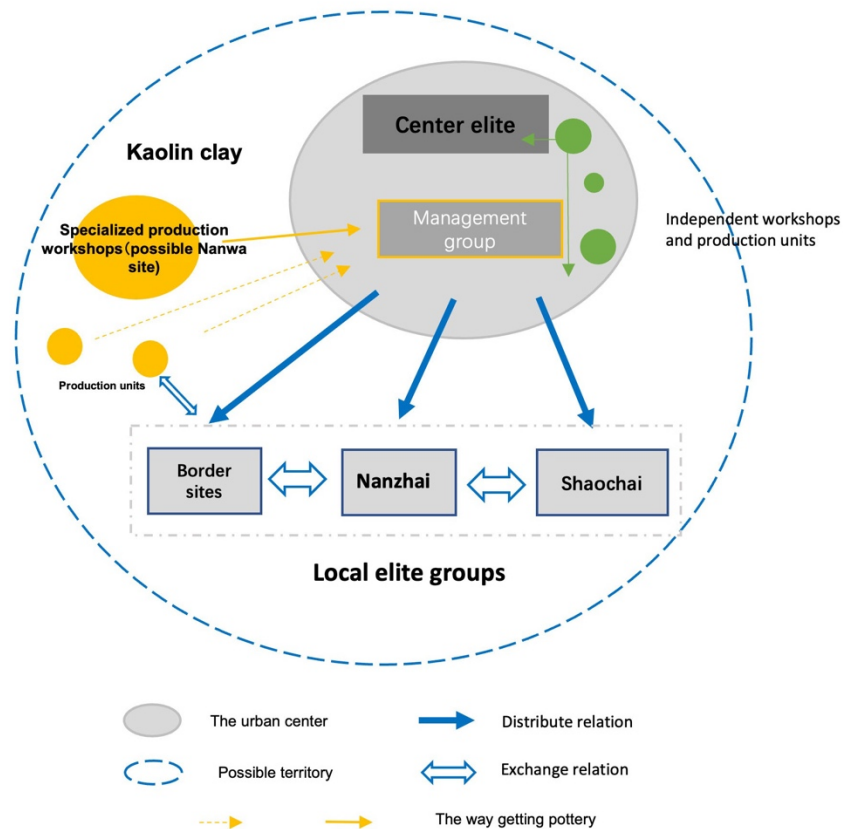


Figure 75 The pottery production system of Erlitou society

All in all, the production of white pottery and the limited incorporation of centralized power above demonstrate the flexibility and social heterogeneity of centralized political power in the early state formation period. The central power was able to adjust its resource acquisition strategy according to its own needs and different political and economic changes, which was fully demonstrated in the acquisition of white pottery. Nanwa's relatively free production also enriched the diverse social relations. In contrast to the previous traditional centrally dominated political-economic model and the dichotomous relationship between the elite and the commoner, ordinary producers were also closely linked to the regime's formation, and ordinary workshops became an important part of the early central political system of rule through

subscription and intervention of the elite.

5.4 Summary

This section began with an analysis of the settlement arrangement and burial behavior at the Erlitou site. This part investigated the complex social structure of Erlitou society, including a high degree of social differentiation, a strong central authority, the social structure and relationship between the center and local. Then, this chapter continues to investigate the production system of Erlitou society based on direct and indirect evidence. Even though the production tools and kilns are seldom found inside the Erlitou, the production units is considered to locate at the margin area of the site with large quantity of output. The examination of pottery has shown a fluent tendency of change in different phases. The clay for pottery has clear distinctions based on different social meanings. The pottery experienced standardization trend from phase 2 to 4 in size and shape. However the late stage phase 4 has witnessed a diverse trend again. The consumption pattern of pottery could also divide into 3 types based on different social and practical needs. Based on these evidence, the white pottery (prestige pottery) is produced in a separated specialized workshop while other one was produced inside the Erlitou site with independent workshops.

Chapter 6 DISCUSSION: the comparison of pottery production system between Taosi and Erlitou culture

6.1 Introduction

This chapter will bring together the data and results from spatial arrangement of production facilities, standardization and differentiation of pottery attributes, and exchange pattern analysis in both Taosi and Erlitou cultures to test the hypothesis presented in Chapter 2 and discuss the relationship between pottery production specialization and state formation.

6.2 Hypothesis testing

6.2.1 HD1: Craft landscape

HD1-prestige or luxury pottery

The production units producing prestige pottery have changed dramatically in landscape and scale from the Taosi to the Erlitou society. Firstly, through the analysis of the settlement and production units, the study found that the units producing burial color-painted pottery were still located in the household context in early Taosi society. These production units are mixed with the production of general pottery and other craft production. There was no separation from the household economy. On the contrary, by the Erlitou period, the white pottery production units were believed to be located in Nanwa. The white pottery production units that existed at the Nanwa site were separated from other living areas and burial areas, and multiple pottery kilns were found clustered together and equipped with supporting wells and other equipment for pottery production. However, there is no clear evidence showing such production units were directly related to the Erlitou regime. The distance between the Nanwa site and the Erlitou site is relatively far. Unlike the bronze and turquoise workshops, which were

located directly around the palace area and could be directly controlled by the elite at any time, such a far distance may show that the workshops in Nanwa may have a certain degree of freedom. Direct evidence of production units producing non-white drinking vessels was also not found within the Erlitou site. Thus, the examination of the landscape is only partially consistent with the original hypothesis.

HD1-ordinary pottery

The results of the investigation on direct evidence of pottery production can provide evidence for the deepening degree of specialization. First of all, a large number of household-based production units were found within the Taosi site, especially in the early period, concentrated in the northern part of District 1 (Figure 19), which is a typical household production pattern. In this case, although pottery may have been produced for exchange within the site, it remained within the framework of a household economy with a relatively low level of specialization. Although the middle and late periods showed some tendency toward specialization, the range of products was also intended to supply the neighborhood with utilitarian pottery. On the other hand, no large-scale pottery production units were found at the Erlitou site. In this case, pottery production activities were not concentrated in the central Erlitou area but may have been located at the periphery or even in the surrounding rural area, supplying the large daily demand of Erlitou city. The new findings from pottery workshops also support such ideas. Specialized production units located in the margin area or rural area produced large quantities of everyday pottery for exchange with the city center, which was a typical feature of the ancient urbanization process. The central area of the urban area was already occupied by facilities related to political power, and production activities of lower status or not receiving control from the regime gradually gave way and moved away from the central area to the periphery or even to rural areas.

6.2.2 HD2: Standardization and differentiation

HD2-prestige or luxury pottery

(1) Clay

In terms of clay selection, the prestige pottery in Erlitou culture has received more special treatment than the pottery in the Taosi site, particularly the use of special and luxury raw materials to distinguish between the prestige pottery and the utilitarian pottery (Figure 52). Furthermore, the drinking vessels from the Erlitou culture area were differentiated into two categories: white drinking vessels and other material ones. The white ones are made of Kaolin clay, which is located around more than 30 km from the Erlitou site. On the other hand, painted pottery in Taosi site burials differs from utilitarian pottery, but the degree of significance is lower than in the Erlitou culture. They were still made from the common local soil from the area surrounding the Taosi site.

(2) Shape and size

In the examination of standardization and differentiation of prestige from both cultures, jars with a large orifice and Dou from the Taosi site and He and Jue from the Erlitou site were selected for examination. The comparison of CV on dimensions revealed that the drinking vessels from Erlitou are more standardized than the jars and Dou from Taosi. The CV of vessels from Taosi is 8.19 and 10.43 in the top burials. The CV is much larger in the secondary elite burials (Table 18). Then, the CV of drinking vessels shows a smaller value in the 3rd and 4th phases (Table 45), even though it was a little larger in phase 2. The lowest CV of He and Jue at the Erlitou site are 4.31 and 5.57. Therefore, overall, the CV for prestige pottery from Taosi is higher than that of Erlitou, indicating the prestige pottery in Erlitou is more standardized in size measurement than the ones in Taosi site (Table 53).

In terms of shape attributes, Erlitou drinking vessels, especially white drinking pottery, are also more standardized than painted pottery from Taosi. In the shape analysis of the Dou and Jars in Chapter 4, the results show a clear variety, and the degree of variation does not differ much from that of their non-painted counterparts (Figure 40 and 41). In contrast, the drinking vessels already show a certain degree of standardization with their low CV results, and the white pottery has a smaller range of variation than the non-white pottery (Figure 70), indicating that the white pottery is more standardized in shape than other drinking vessels. As a result, painted pottery presents a variety of situations in burials and does not differ from ordinary, unpainted pottery. In contrast, white drinking vessels show a clear case of standardization.

In conclusion, the Erlitou prestige pottery shows a higher level of standardization than the painted pottery from Taosi in both the standardization examination of shape and size dimensions. Such a trend implies that the production of Erlitou received more elite intervention and was at a higher level of specialization in the production system.

Table 53 The comparison of CV result between Taosi and Erlitou site

	CV	
Taosi presitge pottery	Jar(in elite burials)	10.43
	Dou(in elite burials)	8.19
Erlitou prestige pottery	He	4.31
	Jue	5.57
	CV(average)	
Taosi ordinary pottery	Jia	33.73
	Jars	19.04
	Dou	34.6
Erlitou ordinary pottery	Jars with deep abdomen	7.86
	Zun	19.8
	Dou	17.48

HD2-Ordinary pottery

(1)Clay

The pottery of the two cultures itself also reflects a deepening pattern of

independent specialization. The result of testing the pottery clay has revealed that there were no significant differences between the raw materials of the utilitarian pottery, which were produced from locally sourced materials. However, the raw materials of ordinary pottery from Taosi are the same as those of colored-painted pottery, but their standardization degree is less than that of burial pottery (Figure 26). The raw materials of ordinary pottery from Erlitou, on the other hand, are distinguished from precious pottery such as white pottery. The evidence shows that there is only variation in differentiation, and the selection of raw materials for ordinary pottery produced did not have a trend toward standardization.

Then the comparison of the standardization of the pottery itself is important evidence for examining the level of specialization. Unlike prestige pottery, which is produced by the will of the elite, the production efficiency and technical proficiency of the producer could influence the standardization of the pottery itself, so the degree of standardization in utilitarian pottery should be positively correlated with the degree of specialization.

(2) Standardization and differentiation

Three groups of pottery with the same function and consistent social role were selected for comparison here. They have the same function and the same distribution of excavation contexts, ensuring that the other cannot influence the standardization comparison result.

Cooking vessels: jia and jars with deep abdomen

In terms of the standardization of their rim sizes, the Jia from the Taosi site shows a high level of variation with a CV of 24.76 (Table 18). The jars started with a CV of 15.67 at the Erlitou site in the 1st phase, and while there is a little increase in CV in the 2nd phase, the CV of the 3rd phase rapidly became smaller and reached a lower level lasting into the 4th phase (Table 39). Therefore, as a cooking vessel, the jars from

Erlitou show a small CV and a tendency to standardize over time. This suggests that the production of the jars may have been more concentrated and intensive than that of Jia, with a higher degree of specialization among the producers.

Furthermore, as shown in chapter 5, the jars from the palace area did not differ in shape significantly from those of other areas and were rapidly standardized after the third phase (Figure 52), suggesting that the jars used by the elite in the palace area were also likely to have come from specialized pottery production workshops at the margins of the site.

Storage vessels: Jars with large orifice and Zun with large orifice(Dakouzun)

Jars with a large orifice and Zun with a large orifice are the typical storage vessels in the two cultures. They were both found in the burials and used in the living area. In the comparison of CV, similarly, the jars with large orifice from the Taosi still have a higher CV value of 19.04 (Table 18), while the Zun of Erlitou site, although they have a higher CV value in the palace area, are also lower than the jars with large orifice by the fourth phase (Table 41). The CV of Zun from other areas is smaller than jars from the Taosi site, so overall, the Zun of Erlitou are more standardized than the jars in the Taosi (The comparison of average CV is shown in Table 53).

Special Cookware: Li

The Li is a relatively special cookware in both societies. The migrations brought the Li to the urban center, but it was gradually produced locally at the sites. They both appeared at the peak of their respective central sites, persisting until the final site collapse. In the comparison of standardization, although the CV decreases significantly from the middle to late Taosi period, it is still greater than 20 (Table 22). The CV of Li from the Erlitou site increased from 17.23 in phase 3 to more than 30 in phase 4 (Table 43). Therefore, Li has a high value of CV in both cultures, which indicates their low level of standardization.

It is understandable that the scale of production and technology are in an immature state compared to other cooking vessels because they were brought in by outsiders. It also appears that the process of localization has not completed the popularization of mass production and that production remains relatively unspecialized.

Therefore, the standardized comparison of the three pottery groups illustrates that the production of different pottery was differentiated. The standardization of pottery in the first two groups confirms the increased level of specialization in the production of utilitarian pottery from the Taosi to the Erlitou period. In Taosi society, production units were small in size and scattered in the household context. The high value of CV corresponds to such a dispersed and small-scale production activity with a relatively low level of specialization. In the Erlitou society, pottery production units are no longer found in the central area. There are no detailed data on the size and internal arrangement of production units, but the demand and products from the Erlitou site and the attributes of pottery can reflect the level of specialization. The standardization of pottery mentioned here in Erlitou is a result of the large demand at the Erlitou site. At this point, a large number of people had moved into the Erlitou site, and the period's peak had arrived, so they required a large supply of pottery. In contrast, only a few pottery-making-related devices have been found among the remains discovered so far, which is in stark contrast to the large demand. In order to meet the large demand, potters inevitably had to work more efficiently, and such a situation leads to the examination of standardization results in line with the mechanized standardization model mentioned in the theory chapter.

Besides the rise of standardization, the unchanged level of standardization in some types of pottery indicates the possible same production organization of these pottery. The level of standardization of Li has remained low, indicating that small production units with a low level of specialization also existed in the two sites.

6.2.3 HD3 consumption and exchange pattern

HD3-Prestige pottery

In terms of prestige pottery consumption patterns, the Erlitou site has a more diverse consumption scenario than the Taosi site. The painted pottery from Taosi is only found in burials and has no practical function; it is more symbolic to show off feasting abilities and the dominant role of ancestor worship in rituals. Erlitou's drinking vessels, on the other hand, are not only found in high-ranking burials but are also consumed in palace areas, have a practical use function, and have appeared in a wide area as a symbol of central power. Such changes indicate that the pottery ritual system became more mature in the social system, produced an expansion in function as well as symbolic meaning, and played an important role in maintaining regional political relations.

In addition, the consumption scene of Erlitou prestige pottery is more restricted than that of painted pottery from the Taosi site. The painted pottery was based on the original vessel type in the commoner living area, and after the imposition of color, it entered the mortuary environment and became a ritual vessel. That is to say, in addition to the elite burials, other consumption scenes can also get similar pottery, only lacking the ritual process of painting. On the other hand, consumption of Erlitou drinking vessels existed only in high-ranking elite contexts, such as palace areas, high-ranking burials, luxury craft workshop areas, and local settlement center sites, and no other contexts could obtain similar vessels. This indicates a pattern of prestige pottery consumption that has become a complete monopoly among the elite. Thus, the consumption pattern of Erlitou prestige pottery is more complex than that of painted pottery at Taosi and more exclusive through the intervention of more centralized political power.

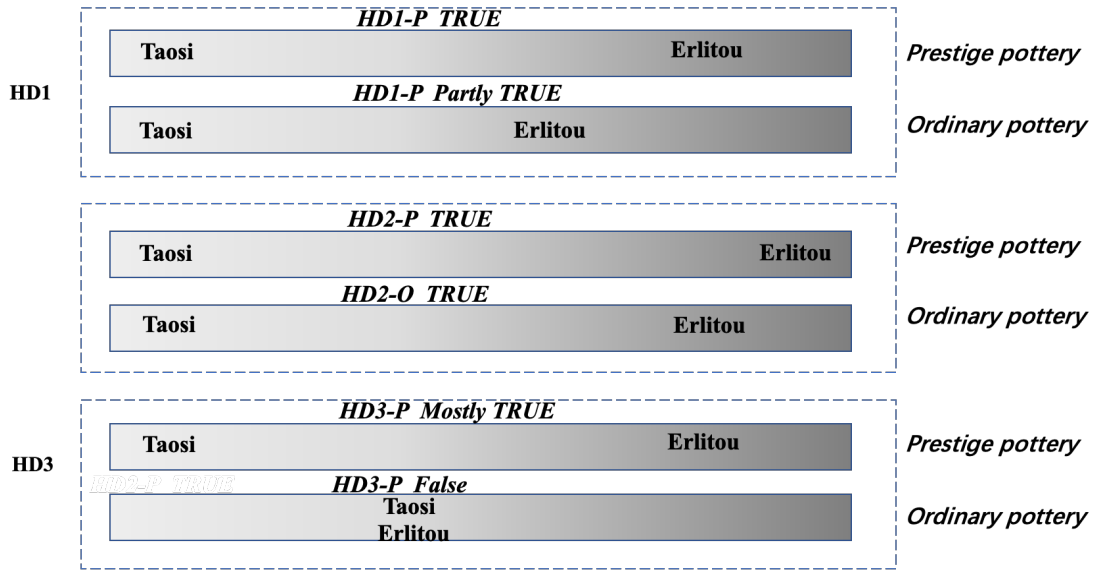
Furthermore, the ways in which prestige pottery vessels were exchanged also differed greatly between the two cultures, including the way they were acquired and the mode of distribution. In terms of access to prestige vessels, those from Taosi originated from individual production units within the site and did not receive strict control. The ceremonial vessels from Erlitou, however, likely came from the Nanwa site, which was located at a greater distance from the Erlitou site (Figure 73). Such a geographical

distance may require a dedicated management group at the Erlitou Center if the core elite need such precious and exclusive white pottery. The nature of the exchange of white pottery between the Nanwa and Erlitou sites is not yet clear, but it is undeniable that Nanwa exported large quantities of white pottery products to Erlitou, and it is a highly specialized production base, indicating that the Erlitou elite had acquired white pottery from a fixed, specialized production organization.

In the distribution pattern, although prestige pottery was used and distributed by the elite in both cultures, a more stable and fixed distribution pattern was formed in the Erlitou culture. First of all, in the burials, drinking vessels were not only found in the top elite tombs but also in the secondary tombs. And the higher-level burials tend to be buried with the whole set of drinking vessels, including warming wine wares and drinking wares (like He with Jue), while the lower-level burials tend to use Gu to replace the drinking ware Jue. Due to the invention of bronze Jue after the third phase, the pottery Jue suffered a certain downgrade, primarily appearing in secondary-ranked burials (Table 49). The painted pottery at Taosi, on the other hand, was almost evenly distributed among the elite burials (Table 20), with no differentiation based on elite rank, including the combination, quantity, and even the decorative patterns of the pottery. Furthermore, the distribution of prestige in the Erlitou culture may have extended beyond the Erlitou site itself and may have influenced far more than the urban center. But the distribution of prestige pottery in Taoist society was confined to the site itself.

HD3-Ordinary pottery

The consumption pattern and exchange pattern of ordinary pottery did not change significantly from the early Taosi period to the Erlitou period. The ordinary pottery was basically for daily consumption, so there was no special change in consumption pattern. In addition, the circulation of common pottery was also restricted inside the settlement area, and no cross-regional exchange of common pottery was found in the Erlitou society, which remained a self-sufficient pattern within the site. Therefore, there was no significant change in the mode of exchange.

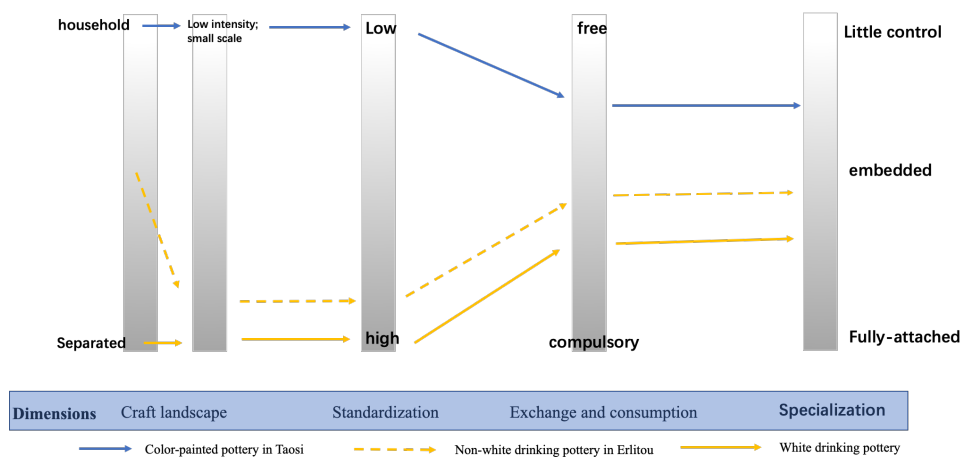


The marked positions represent the relative degree of specialization in each dimensions

Figure 76 The hypothesis testing results

6.3 Changes in pottery production from the Taosi society to the Erlitou society

By testing the hypotheses on the three dimensions, the research gets a clear picture of the overall change in specialization. Combining the previously mentioned criteria for judging specialization, we can compare the degree of specialization in pottery production in the Taosi and Erlitou societies.



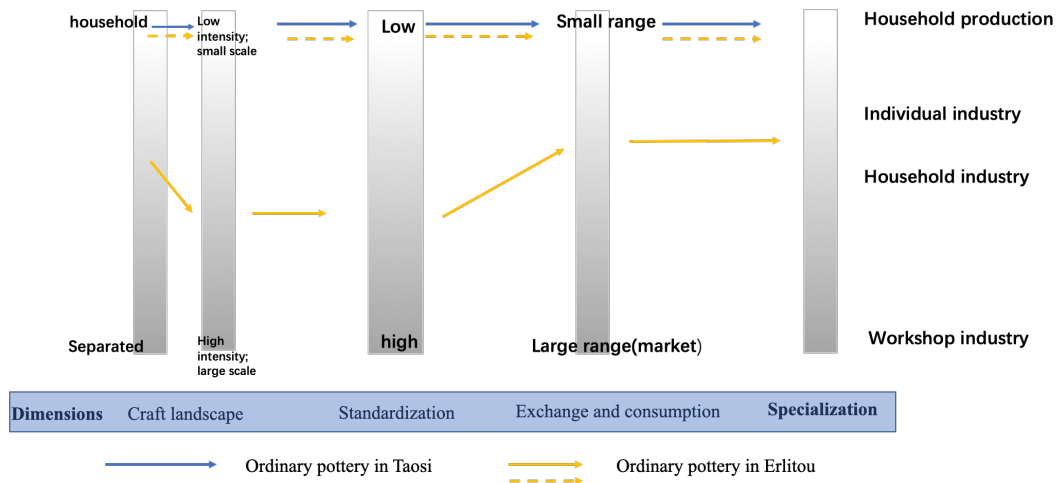


Figure 77 The identification of specialization in Taosi and Erlitou

Although the general trend of specialization increased during the formation of the early state, the rate and form of change in different dimensions were different (Figure 77). The most significant changes happened in the standardization and differentiation of production, which is dimension 2. Standardization was often due to advanced production techniques, increased production efficiency, and increased intensity of production to meet economic interest (Stark, 1991). Therefore, during the early stages of state formation, the changes in production means are the most direct. In addition, the establishment of the ritual system also requires the elite to increase control over rare pottery to create a unified symbol of power and establish a unified political and cultural identity over a wide area, so in the early state formation process, pottery standardization both in terms of economic needs and political and social integration would have arisen along with the increasing degree of specialization. Such a link has also been proven in other early states, such as early Mesopotamia and India Valley (Blackman et al., 1993; Maisels, 1999), as mentioned in Chapter 2. The secondary obvious change happened in the craft landscape dimension. Both luxury and common pottery were produced within the context of household production in the Taosi society, while the separation from households and the formation of independent production workshops were completed in the Erlitou period (Figure 78). White pottery, in particular, was produced in a separate workshop far from the central Erlitou, which gave rise to specialized production potters as well as specialized managers. Finally, exchange and consumption patterns changed to a less pronounced degree than the previous two, except for the consumption patterns

of prestige pottery in Eritou society. The change in consumption patterns of prestige pottery as a symbol of power and social relations in ritual activities is significant. Although redistribution existed in both Taosi and Eritou, and luxury pottery circulated and was used within the elite groups, the fixation of the combination of drinking vessels in Eritou, the broadness of the redistribution, and the ability to shape the common culture far exceeded the color-painted pottery in Taosi society. However, the exchange pattern of prestige pottery does not conform to the hypothesis. Although drinking vessels received the control of the elite and the exchange relationship could be unequal, this control did not result in so-called full-attached workshops, and some of the white pottery was made by specialized Nanwa production workshops, while non-white pottery drinking vessels as well as utilitarian vessels for the elite were assumed to be produced by common people's production units within the site and were not strictly controlled. Such a pattern is more like an order than an attached form like bronze and turquoise production. On the other hand, ordinary pottery saw little change in exchange and consumption patterns, suggesting that it was less affected by social change in the early formation of states.



Figure 78 The basic pattern of pottery production in two cultures

In addition to the different production dimensions, there are significant differences in the degree of variation in the early state formation of pottery with different social and functional attributes. As mentioned above, although both ordinary and prestige pottery developed standardized characteristics, some of the utility pottery remained unstandardized, and the overall level of standardization of prestige pottery was much higher than that of ordinary pottery. In the other two dimensions, the degree of variation in prestige pottery is also far more drastic than in general pottery. Thus, different social attributes had a greater impact on the rate of change in pottery specialization and its

relationship to society, especially during the formation of the early state. This also shows from another side that the dominant role of elite behavior in the early state also had a profound impression on pottery production as well, and was even the main motivation for the changes in pottery production specialization.

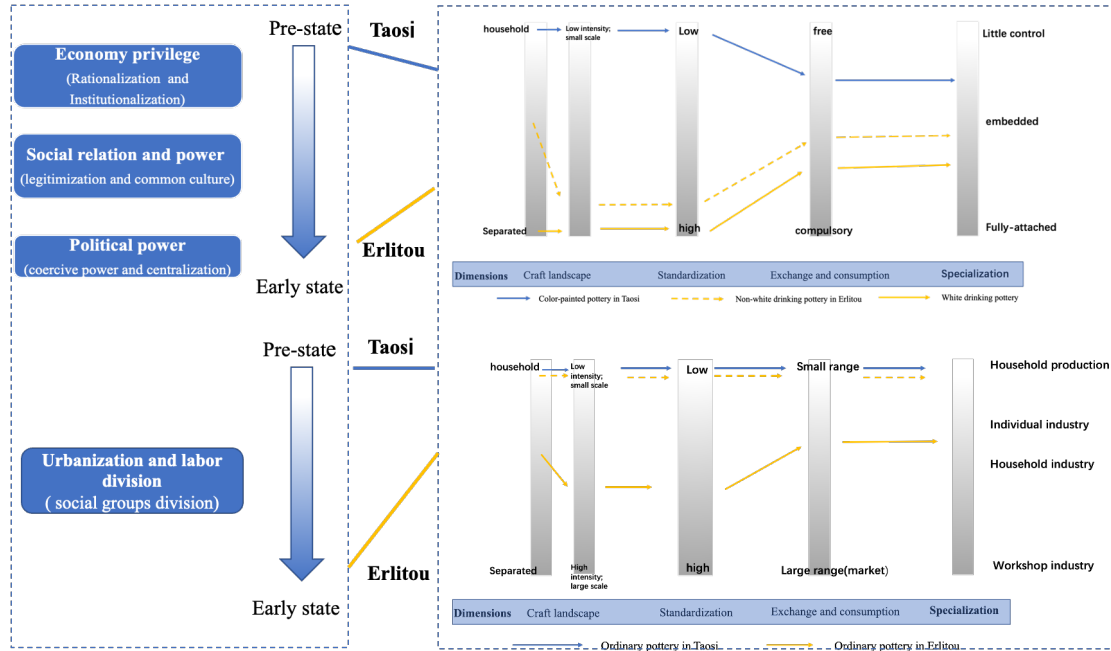


Figure 79 The amended model with the result of the dissertation

6.4 The relationship between pottery specialization and early state in Chinese archaeological context

The early state was formed as a result of the social complexity of changing leadership strategies and increasing centralization, as well as the hierarchy and differentiation of social organization (Rothman, 2004; Crumely 2005). In Chinese early state formation, the social integration and urbanization plays the critical role. As a result, the pottery specialization also showed a dynamic and active response to the social integration and urbanization during this process.(Figure 79).

6.4.1 Political factors and the dominant role of elite: the leading factors in the specialization of pottery production

The most obvious change in early state formation was the institutionalization and legitimization of political structures (Claessen and Skanlinik, 1978). The change of prestige pottery in the process of early Chinese state formation can prove that political factors were the main motive for the specialization of pottery production. The dominant role in social integration in terms of political structure, economic privilege and social cultural commonality has an important influence on pottery specialization.

Taosi society is already a highly stratified and relatively complex society, but the social system developed to a more complex level when it came to Erlitou society, including the centralization of the political system and the gradual establishment of central authority over a wide area (Liu and Chen, 2012). The different organizational forms of pottery production show such changes in the structure of political power. In the pre-state period, the political center's institutional nature and centralization of authority remained somewhat limited compared to the state (Miyamoto, 2020). The pre-state leaders were able to acquire some precious objects and luxury goods through remote transactions, stabilizing their economic privileges and serving as status symbols, but they did not form an institutionalized system for such acquisition, so they only used their power to obtain special pottery from ordinary potters and production units, giving such pottery social and religious significance through a series of rituals as shown at the Taosi site. In this situation, the specialization of pottery was limited to a small number of ritual uses for the elite, and such a degree of specialization is limited.

The state period was characterized by a more pronounced political and economic privilege for the palace elite and a centralized and institutionalized central authority that drew on previous traditions in the early years of the state to seek more stable and more isolated units from ordinary production (Jaang, 2022). Such an operation is consistent with the general notion that prestige items were controlled by the elite and served as a medium for the social elite to convey an ideological message of inequality for the right (Liu, 2003; Underhill, 2002). Therefore, the Erlitou society, as an early state, wanted leadership to be enhanced and institutionalized on a wide territory, and the leaders, in their desire for social organization, political system and cultural integration, urgently needed luxury handicrafts to achieve such goals, not simply to define leadership and

manifest wealth power, but more fixed ritual connotations and wide recognition and acceptance.

Firstly, this reflects the fact that the organization of pottery production also became more centralized and specialized under enhanced political demands and political interventions, which is also consistent with the case of Inka-style pottery in the Wanka III period (Costin, 2004). At the same time, the strengthening of the regime over a wide territory also required prestige pottery to play an important stabilizing role, which thus also resulted in a deepening elite involvement in prestige pottery production. Such a changing tendency is somewhat consistent with the political model proposed by Brumfiel and Earle (1987). The strengthened central political power did have an impact on the production system of luxury pottery, resulting in changes in production components including the organization of production, production means, product characteristics, and exchange. It also shows the positive link between political processes and the specialization of pottery production.

Then, the fixed ritual system was also gradually formed under the thirst for institutionalizing state leadership. Unlike the pottery and jade vessels that were chosen as symbols of status and power through burial rituals in the Taosi society, the ritual system in the Erlitou society was a stable combination of pottery drinking vessels, bronze vessels, and turquoise (Qin, 2022). Drinking vessels have a long tradition in China as a socially luxurious craft item, existing from the Dawenkou society to the Erlitou, Erligang and even the Zhou dynasty (Qin, 2019). The drinking of alcohol in feasting or burial ceremonies has always been seen as a means of harmonizing social relations and stabilizing social order (Underhill, 2022). In pre-state societies, drinking vessels tended to appear separately only in high-ranking burials within the region, and although there was influence between different cultural areas, there was no unified norm of use. Erlitou society, on the other hand, greatly increased the ritual meaning given to drinking vessels, using combinations of white drinking vessels (drinking vessels: Jue and warming vessels: He) in top burials from the early stages of social integration to show top nobility and coordinate social power, with secondary burials using Gu as a drinking vessel instead of He (Table 49). And outside the Erlitou site, the

top burials of important large settlements have separate pottery drinking vessels with matching turquoise to form a political communication circle for the upper local elite as shown in the mortuary analysis. Furthermore, the ritual system was constantly being adjusted during the social integration phase. In the early stage of social integration, the white drinking vessels, as the most valuable ritual vessel, functioned together with non-white drinking pottery. Then, the invention of bronze drinking vessels in the third phase of Erlitou replaced white pottery and became the exclusive possession of the top elite. The non-white drinking vessels combinations in the tombs were downgraded from the top tombs to the secondary elite tombs in the Erlitou site (Table 49). White pottery also gradually disappeared from the Erlitou ritual system, and non-white vessels continued to function in the central secondary elite group as well as in local settlement centers. This shift reflects the fact that as social integration progressed, the Erlitou elite continued to adjust their control strategies according to the preciousness of the materials and the enforceability of control. The distant Nanwa site was not easily controlled and the technology of white pottery production was not exclusive to the central elite. Such situation was not suitable for the mature integration stage of Erlitou society, white pottery was therefore abandoned, and pottery production at the Nanwa site gradually died out after Phase 3. Instead, elite continued to invest in the production of turquoise and bronze around the palace area, while non-white drinking wares were probably produced in semi-controlled specialized workshops (Peng, 2013). This reliance on the social meaning of drinking ware in the integration process and the way in which intervention in production was adjusted according to the degree of exclusivity of the production process reflects the pursuit of economic privilege and common cultural leadership in social integration by the elite of the early Chinese state and constitutes the most influential factor contributing to the deepening specialization of pottery production.

Interestingly, the Erlitou phase 3 witnessed the phenomenon that the invention and gradual use of the bronze vessels were accompanied by a pottery standardization trend for both prestige use and ordinary use. In the phase 2, the ordinary pottery has shown the diverse trend both in shape and size, however, by the third phase, the degree of

variation in both cooking and storage vessels, such as deep-bellied jars, was greatly reduced, and the standardization of everyday pottery, especially in the palace area, increased rapidly and was higher than in the general area. Such consistency also indicates that political factors and elite behaviour had an impact not only on prestige pottery during the process of social integration, but also on the standardization and specialization of ordinary pottery.

However, Erlitou society is still in the primary stage of the early state, and the political structure is still in a stage of enhanced transition, so that the deepening of specialization does not occur obviously in every dimension. Instead of controlling the entire production system and hiring fully attached potters, as the elite in the Inka empire did, the Erlitou elite preferred to control the acquisition and later consumption distribution stages without forming a highly attached production organization, so that Erlitou's political power influenced the production system to some extent but did not result in a complete change of the entire production system into an attached one.

As discussed, the production of white pottery was not a centrally controlled and produced in the attached workshop. Instead, in the early Erlitou period the elite adopted a more economical and expeditious method which importing white pottery products from established white pottery production workshops and distributing them for consumption. This practice was adapted to the context of social integration from polycentric to monocentric in the early state formation. In the early stage of this process, initial state power limited the elite's ability to control the craft production. Thus the elite may not be able to control all types of artifacts. The pottery itself was not the first choice for the elite as prestige items, such as Kerner (2010) finds out the pottery and metal in a different role in the social structure and creation of identity so that the metal production is attached to the elite and pottery production is independent from the elite control. The similar situation can also be seen in the Mesopotamia. In Erlitou situation, the raw materials for white pottery were relatively easy to obtain compared to bronze and turquoise and the technology of white pottery had matured in the Longshan period and was not exclusive to the Erlitou elite. Therefore, if the socially significant white pottery was chosen as a symbol of the ritual system in the early stage of political

integration, it was not necessary for the elite invest power and energy to monopolize its technology and production. The quickest and easiest way to obtain it was to intervene in the original common people-based technical production organization. Therefore, The primitiveness of the early state also influenced the pattern of specialization. In addition to the impact of enhanced political intervene on pottery production, the change of social regime also had a certain degree of impact on pottery production at the Erlitou site. All kinds of pottery in this study have variation trends in the late stage of phase 4 of Erlitou site, suggesting that the original production organization may have changed. As mentioned in previous studies, the controllers of the Erlitou site during this period may be the proto-Shang group, and their main purpose of occupying the Erlitou site was to produce exquisite bronzes for the elite. Under such circumstances, there may be Shang group living at the Erlitou site, participating in or supervising the production of bronze vessels. The emergence of such new groups and rulers increased the demand for new forms of pottery. The production of pottery does not require high technology like the production of bronze ware, therefore, new social members may also hire local potters or bring potters into Erlitou site to produce pottery of Proto-Shang style. This situation may lead to the variation of pottery in shape and size, which is different from products from the independent specialized workshops in the phase 3 and early stage of phase 4. In summary, pottery production in the early state formation of China has a close realtion to the rise and fall of sociopolitical power.

6.4.2 The urbanization process: a facilitating factor for the specialization of pottery production

The emergence of the state was often accompanied by further urbanization, and the differentiation of social groups brought about by urbanization also influenced the development of specialization in pottery production. Erlitou urbanization and the continuous entry of immigrants constantly impacted the original economic system and social organization system. Unlike the early Taosi society, which remained clan-based, the Erlitou society relatively broke away from the original organization and continued

social integration through continuously absorbing new immigrants as well as external cultural influence. In general, there was no core unified arrangement and management for the production of specialized luxury goods in settlements with integrated bloodlines (Pei, 2019). In the late prehistoric period, although there may have been some differentiation of production and division of labor, these were unrelated to the commodity economy. The key to the social division of labor in this period lies in the fact that the settlement organization has integrated interests, leading the members of the society to produce and consume craft as a community. Within the group, the person who has mastered high-tech production takes on the role of production craft. It is not related to a special social identity. Therefore, under such social organization, the pottery production system at the Taosi site is relatively simple, and the level of specialization is low. Pottery production is still relied on by households. The producers are still family-based multi-project practitioners, and the organization is based on the family or the community as a production unit (Hirth, 2009). Even though the demand for special colored pottery stimulated a certain degree of production differentiation, it did not break away from the common pottery production unit. A similar situation was common in late Neolithic China, such as at the Xiaojiaju Site (Hubei et al., 1999) of the Shijiahe Culture(石家河文化).

The situation has changed a lot in Erlitou society. In the context of deepening urbanization, the entire Erlitou society has a clear hierarchical division and a more diverse organization. Inside the Erlitou site, there is a dense population and differentiation based on social rank and production activities (Liu and Xu, 2007). The inhabitants were engaged in agriculture and various craft production activities, producing goods for the urban elite and commoners. The social structure is relatively simple outside the Erlitou site. At the same time, the Erlitou social organization is deeply dependent on the urban context. The growing urbanization absorbed a large labor force, and the differentiated urban functions also had a profound impact on pottery production(Liu and Chen, 2002).The various social organizations resulted in the production of numerous craftsmen groups on the Erlitou site, including professional

pottery, who may have gone beyond the so-called household community to independent unit-based production (Costin, 1991). Although the current evidence only mentions that the pottery production workshops were located in general residential areas on the northwest edge of the city, it can already be assumed that they were physically separated from other craft production such as bronze, bone, and turquoise, and from the production of white pottery as well. In other words, these workshops were probably specialized in the production of pottery, with a high degree of specialization. Besides that, the relative remoteness of the workshops from the palace area, having given up the central area to other craft production, indicates their relatively low social status (compared to bronze craftsmen), and the distance from political power also suggests a high degree of autonomy. Although these provided drinking ware and other pottery for elite daily use, they were not associated with the elite and were a benefit exchange. At the same time, these workshops supply the inhabitants of the urban area with pottery. As mentioned before, increasing standardization and the growing population of Erlitou also suggest a deepening specialization in production. This specialization is the result of increasing demand in the context of urban development and the division of the labor force away from the original communal organization. Moreover, the small fraction mentioned in Li in Erlitou suggests that, in addition to the increased specialization of workshops, it is likely that small-scale, non-specialized production also existed for producing some unpopular pottery. The existence of such diverse organizations is also one of the manifestations of social complexity (Costin, 2004).

6.4.3 The relationship between pottery specialization, pottery production and early state in Chinese archaeological context

From the analysis of the two aspects mentioned above, we can discuss the role of pottery production in the early formation process of the Chinese state and the characteristics of the Erlitou early state. From the Taosi society to the early Erlitou society, and then to the late Erlitou society, the formation of the early Chinese state can be seen as being dominated by the elite group, from a multi-center to a single-center

system, and constantly deepening the process of social integration. As a wide territory state society, the Erlitou elite continuously strengthened their economic privileges and political center status by controlling luxury goods and forming cross-regional trading or tribute systems. Gradually, they enhanced control over the surrounding areas through a common sense of ritual instead of redistributing through kinship proximity. Additionally, to further legitimize the central state power, the distinction of prestige craft and the division of settlement grades became increasingly clear, gradually forming the influential ‘drinking vessel’ ritual system. Furthermore, with the continuous increase in population and influx into the central Erlitou, the urbanization process of the Erlitou site has been deepening under the joint influence of political and economic factors, reshaping the economic activities and social relationships within the Erlitou site.

Under this special formation pattern, pottery production played an important role in the process of state formation. As mentioned above, the production system of pottery drinking vessels showed that the state elites used symbolic means to enhance their role and with the increase of state power, their control over pottery drinking vessels gradually strengthened. This was gradually established and reflected in the wide-ranging influence of the Erlitou state, as it used the ritual system to consolidate state power and achieve social integration. In the verification of the three branching hypotheses(Figure 76,77), it was found that the elites were most involved in the production means and redistribution of pottery, especially in the highly standardized white drinking vessels. Even in the phase 3 and 4, when white drinking vessels gradually disappeared, the production of non-white drinking vessels became more specialized and highly standardized. Although they were not considered the most valuable ritual objects by the top elite, they still played an important role in maintaining social relationships and coordinating the wide-ranging political hierarchy, reflecting that the Erlitou state had formed a political ritual system recognized in a wide territory with pottery drinking vessels as its core. In the latest stage of Erlitou society, due to the political center being conquered by other ethnic groups, the standardization and specialization of pottery production declined significantly, suggesting that the production of pottery vessels also gradually declined. Therefore, the deepening of

specialized production of precious pottery and its prosperity was an inevitable phenomenon in the process of state formation in early Chinese states, with the intervention of the elite being the most obvious factor in its deepening. The specialized production of pottery served the state ruling in consolidating economic privileges, political center status, and the establishment of a wide-ranging ritual system and common ideology. This also reflects the special relationship between pottery production and the shaping of state power in the process of early state formation in Erlitou.

As the Erlitou state's power continued to expand and deepen its control over a wide area, its use of drinking vessels as symbols gradually shifted from pottery to bronze vessels. After the third phase, the state needed more unique symbols to represent its supreme power, and it pursued monopolies on materials and technologies. Therefore, bronze drinking vessels became the highest-ranked ceremonial items that represented state power and were only distributed within the center. Pottery drinking vessels were still used as complementary items to the bronze ones and were distributed and used between the central and local elite group, forming a clear political hierarchy. This shows that as the exclusivity and monopolization of handicraft production increased, the Erlitou state society, in the relatively mature stage of development, pursued the exclusivity of central power and absolute advantage over local power. From the perspective of the pottery production system and specialization, the formation of early Chinese states was a process of the continuous strengthening and integration of elite power over a broad area, with the elite constantly adjusting the production and distribution of luxury goods for both internal and external needs.

The production system of common pottery also was influenced by the pursuit of economic power by the elite during the formation of the state, as well as changes in social organization. In the process of continuous urbanization at the Erlitou site, social relationships transformed from the original blood ties to organization forms centered on small families based on economic and political life in the urban context. Therefore, common pottery also showed a trend towards specialization from Erlitou phases 2 to 4, and was distributed in the form of small units in peripheral areas of the site. In phase 2, there was no apparent evidence that ordinary pottery production was subject to elite

intervention, and it was still produced in diversified forms by families. In Erlitou phases 3 and 4, there was a significant standardization trend in the cooking vessels found in the palace area, which surpassed other regions, suggesting that the elite may have obtained daily utensils from specialized workshops. Thus, this ordering model also reflected the common pottery workers' response to the increasing elite power, raising production standards to meet the nobles' daily needs. Overall, pottery for the elite and the commoner both showed a trend towards standardization after phase 3, indicating that the urbanization development in the state formation process changed the original production relations and patterns. Thus during the formation of the Erlitou state, ordinary pottery even with a little elite intervention produced changes in the production system, becoming more specialized in the context of urbanization. This shows that the division of labor during the formation of the state also inevitably changed the production of ordinary pottery.

6.4.4 Further Enhancement of Specialization: The State after Erlitou

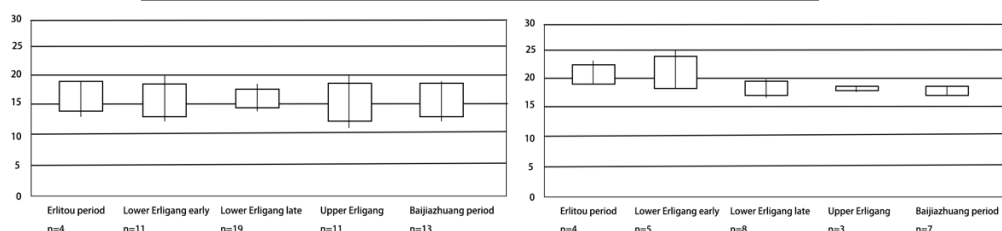
Prospectively, the rise of central political power and the urbanization process have had a significant impact on both prestige and ordinary pottery. Such a trend has also been validated and supported in the subsequent state period in China. With gradual state development and maturation, the degree of pottery specialization and the complexity of the production system became more apparent in the subsequent Erligang (Qin, 2019) and Yinxu (Pei, 2019) periods.

For example, the subsequent Yanshi Shangcheng(偃师商城), only located 6 km from the Erlitou site has witness the deepen degree of pottery specialization. As the regional center after the Erlitou site (Zhongguo, 2013), the Yanshi Shangcheng also existed with a clear layout plan including palace area, storage area, ritual area, workshop area, etc. Pottery workshops could be found in Yanshi Shangcheng (Deng et al., 2022), both near the palace and on the city's outskirts. They are considered the specialized pottery production units, serving the elite and the citizens, respectively.

Qin(2019) conducted a dimensional study of the cooking jars and Li from the Yanshi and found a trend toward standardization in the rims of cooking vessels from the Erlitou period to the Erligang period (Figure 80:1). A possible tendency toward deepening specialization is indicated. Similarly, Reinhart and Michael (2020) used multivariate analysis to examine cooking vessels from the palace area and the pottery workshop area (Figure 80:2) and found a higher degree of dimensional standardization in the workshop area than in the palace area, suggesting that the palace area, as a place of consumption, has a source of cooking vessels from more than just the northwestern workshops, and that the more standardized pottery sizes in the workshop area are consistent with their specialized functional characteristics. In contrast to the previous two comparisons of size distribution across periods and regions, Deng et al.(2022) conducted a quantitative CV examination of the large-mouthed Zun of the Yanshi Shangcheng (Table 54). They found a higher degree of standardization of Zun in the workshop area, proving that a higher degree of specialization existed in the workshop area and that the degree of standardization gradually increased with the development of the workshop. All three examined the trend of standardization of different pottery, proving the existence of ottery production workshops with a high degree of specialization in the Yanshi Shangcheng.

Table 54 The result of size variation of Zun in Yanshi Shangcheng(Deng et al., 2022)

Area/ stage		Number	CV
IV			9.62
Palace area			26.85
IV	3 stage		10.10
	4 stage		3.17
	5 stage		7.08
	6 stage		16.62



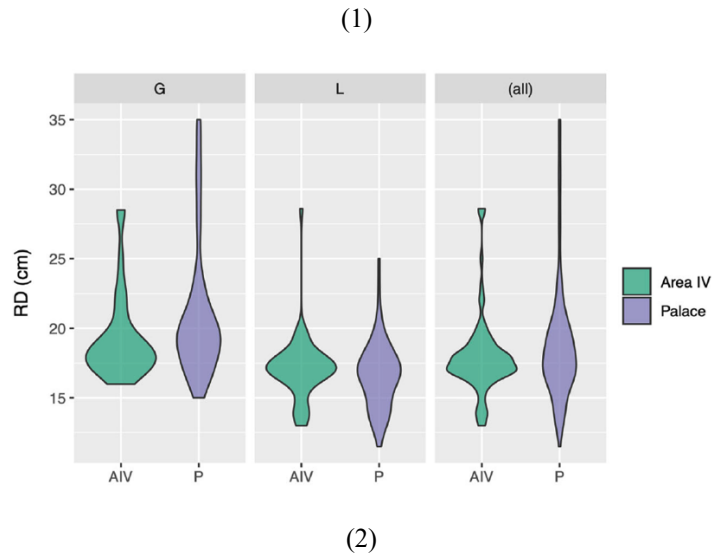


Figure 80 the result of size distribution of Li and Jars (1) Qin, 2019; (2) Reinhart and Michael ,2020

In response to these findings, this study verified the degree of dimensional variation of cooking vessels based on data reported of Yangshi Shangcheng(Zhongguo, 2013). The results (Table 55) show that the CV experienced decreasing from 2nd stage to 4th stage and increasing after 4th stage. Such result is consistency with the result of Zun, indicating the possible changes of pottery production. In addition, in terms of CV values, the cooking vessels: Li and Jars both show a small degree of variability. In the most standardized stage: 3 and 4, the CV of Li is around 10-13, while that of jars is below 5. Compared with the same type of cooking vessels from the Erlitou site, the CV is greatly reduced, indicating that the cooking vessels from Yanshi are much more standardized than those from Erlitou(Table 56). Combined with the discovery of pottery production workshops inside the urban mentioned earlier, it can be shown that the level of specialization of pottery production in Yanshi is higher than that of the Erlitou site.

Table 55 The CV result of cooking vessels from Yanshi Shangcheng

Area	2 stage	3 stage	4 stage	5 stage	6 stage
Cooking li (N=186)					
Total	16.90	12.43	11.50	13.30	19.20

II	18.50	6.82	14.25		
III		13.55	13.69		
IV	17.43	11.49	10.36	12.96	20.08
VIII					18.44
Cooking jars with deep abdomen(N=36)					
Total		4.03		9.74	4.16

Table 56 The comparison of CV results between Erlitou site and Yanshi Shangcheng

	Erlitou site			Yangshi Shangcheng		
	Largest CV	Lowest CV	Average CV	Largest CV	Lowest CV	Average CV
Li	36.18	17.23	27.87	20.08	6.82	14.32
Jars	17.35	7.06	11.92	9.74	4.03	5.98

The further development of the craft production at Yanshi in the late Shang period also supports the profound strengthening of craft specialization by the state. The textual and archaeological evidence suggests that the identity of the artisan in Yinxu certain craft production, such as bronze production and possible prestige pottery production (He, 2022), was already recognized to some extent, and that there was a possible hereditary system. As a result of a strong social identity and a stable hiring and working system, production specialization has grown significantly.

The above examination of pottery production specialization in subsequent cultures at the Erlitou site verifies the general trend: pottery production became more complex and specialized during the formation of the early Chinese state, and the transition from the Taosi to the Erlitou society belongs to the early stages of this process.

6.5 Summary

This chapter tests the hypotheses presented in Chapter 2 and demonstrates that the general increasing trend of pottery specialization during the formation of the early Chinese state. The most notable change happened in the production of prestige pottery under the influence of the elite dominant forces in socio-political and cultural

integration process, both in terms of production landscapes, standardization and differentiation, and exchange patterns. The study also finds that the elite would constantly adjust its intervention strategies for pottery production to meet the needs of social integration. The elite intervention in the pottery production reflects not only the pursuit of economic privilege, political legitimacy, and widespread cultural commonality in the formation of the state, but also their still limited power, which is consistent with the characteristics of the early state. In addition, the new social relations and division of labor that continued to emerge in the context of urbanization also contributed to the development of pottery specialization, but the impact was limited compared to the precious pottery production in which the elite intervened. It did not result in a significant increase in specialization like subsequent Erigang period.

Chapter 7 Conclusion

7.1 Chapter summaries

In chapter 1, the basic research background was introduced including the study tendency of craft situation and problems in the study of pottery specialization and social

complexity in China. This chapter also outline the significance of this study in clarify the specific relation between pottery and early state formation in Chinese context and reclaim the proper application of quantitative method in the ceramic studies.

Chapter 2 is devoted to a summary and critical discussion of the two parts of the theory and previous research. To begin with, we know from reviewing the unilinear and multilinear theories of social evolution that social change, particularly state formation, is diverse and that separate models cannot explain the trajectory of diverse changes in the world, whereas the concept of social complexity allows examining different changes in society from the divergence of different social directions. The formation of early state in China has shown some unique trajectory in terms of social integration and urbanization. Then, the related concepts of craft specialization are discussed. Through the above theoretical review, the study realized that while the importance of specialized production for studying the origins of the state has been recognized, the diversity and specificity of the relationship between specific pottery production and social complexity has not received enough attention, and examining the relationship between social complexity, the emergence of the state, and craft specialization requires further exploration. I therefore propose a research question for this thesis. By analysing how to identify the degree of specilaizaiton, the theroretical model was established to explain the relationship between pottery production and early state formation. The research selected two cultures that represent the process of state formation in early China, the Erlitou and Taosi cultures, as case studies to test and answer the proposed questions and hypotheses in order to explore the special relationship between production specialization and state formation in the Chinese archaeological context.

Chapter 3 described the research materials to be used for the study and the quantitative research methods to be used for different properties of the material. The research as selected direct evidence and indirect evidence from Taosi and Erlitou site based on the statistical requirement and research goal. The study used different research methods for different types of evidence. Spatial analysis is applied for studying direct evidence: kilns, production tools and debris to identify the location and related information on production landscape. Then, multiple quantitative methods are applied

to study pottery. The research used GMM and CV to quantify the attributes of pottery and multivariate analysis method to analyze the quantitative result.

Chapter 4 and 5 dedicated to the detailed summarization of results about pottery production in Taosi and Erlitou culture. The results show that, in the Taosi early period, the production units were mainly found in the household context. And the examination of pottery has shown a relatively low degree of specialization. The clay for pottery, whether used in elite burials or by the commoner, is all from the same area and has no discernible difference. The pottery varied greatly in shape and size but differed in function and social significance. Such differences imply the possible intervention of elites in pottery production, but their power is limited. Furthermore, even though the production tools and kilns are seldom found inside the Erlitou, the production units are considered to locate at the margin area of the site with large quantity of output. The results of pottery have shown the clear distinctions in raw material, shape and size standardization and exchange pattern based on different social meanings. Based on results, the white pottery (prestige pottery) is produced in a separated specialized workshop while other one was produced inside the Erlitou site with independent workshops.

Chapter 6 was a synthetization of all previous chapters of this study into a discussion about the production system, pottery specialization, and its relation to the early state. The hypotheses concerning the specialization of production presented in Chapter 2 were confirmed and tested by the results in three dimensions. In the general trend, from Taosi to Erlitou period, the specialization of pottery production indeed deepen. More importantly, the features of special link between pottery specialization and early state in China could also show in this process. The most notable change of specialization happened in the production of prestige pottery under the influence of the elite dominant forces in socio-political and cultural integration process, both in terms of production landscapes, standardization and differentiation, and exchange patterns. The study also finds that the elite would constantly adjust its intervention strategies for pottery production to meet the needs of social integration. The elite intervention in the pottery production reflects not only the pursuit of economic privilege, political

legitimacy, and widespread cultural commonality in the formation of the state, but also their still limited power, which is consistent with the characteristics of the early state. In addition, the new social relations and division of labor that continued to emerge in the context of urbanization also contributed to the development of pottery specialization, but the impact was limited compared to the precious pottery production in which the elite intervened. It did not result in a significant increase in specialization like subsequent Erigang period.

In conclusion, the changes of pottery specialization during the early state in China is a dynamic process influenced by the social integration process, the role and function of elite in this process and the pottery' function and social attributes in the society.

7.2 Limitations and Future studies

This study generally outlines the changes in pottery production and pottery specialization from the Taosi society to the Erlitou society and summarizes the dynamic relationship between changes in specialization and social complexity in the context of the social development trajectory of early Chinese state formation. However, due to various reasons, especially the lack or insufficiency of data, this study has some limitations and still leaves some questions for further investigation.

1. Although the sample size of pottery in this study meets the basic statistical requirements, the sample size is still small compared with other similar studies, so that it is impossible to compare the characteristics of pottery in each zone in detail at the Erlitou site. This may produce a lack of information on pottery production in the relevant areas. And the study did not cover the full range of pottery types due to the limitation of the sample size, thus also lacking the examination of more types of pottery. A more detailed examination of more types of pottery would be a useful addition to this study if the data were to be supplemented in the future.

2. In the study of the pottery production system, direct evidence, i.e., kilns, pottery tools, etc., is still found to be scarce at both sites, thus making it difficult to judge the production organization in detail.

3. Pottery production techniques are important in pottery manufacturing expeditions and can suggest changes in specialization. However, this study is limited by material and cannot personally observe the traces of pottery production technology and has to rely on previous studies for understanding. Although the pottery production techniques are mentioned in the previous study part, they cannot be analyzed or applied to determine the level of pottery specialization in this study. This is very unfortunate. In future research, it is hoped that the author could have the opportunity to observe and analyze its production technology in order to remedy this limitation.

4. At present, the Erlitou, Taosi, and Nanwa sites are still under archaeological excavation, and much information has not yet been released or has only been mentioned in newsletter, which does not constitute archaeological evidence for this research, and this limits the discussion of this study to a large extent. For example, the excavation of the Nanwa site has only revealed a small area, and there is no evidence to prove whether there is an obvious affiliation between it and the central Erlitou, so more evidence is needed to make a determination in judging the exchange pattern. In addition, the publication of data from the late middle period of the Taosi site is still limited, so the discussion of the social production system of Taosi in this paper can only focus on the early pottery period. With the publication of further archaeological excavations and data, it is hoped that this study can be supplemented and expanded to make the discussion more detailed and convincing.

Despite the above-mentioned limitations that need to be revisited and resolved, this study is still a useful attempt to discuss the relationship between ancient pottery production and social change from a broader perspective. In the future, with the premise that more information will be added to the study, the research will explore more detailed production behavior to enrich the theories related to pottery production, especially the examination of the Nanwa site and the study of the relationship between pottery production at Erlitou and the surrounding sites. The shift in focus in recent years to ordinary rather than luxury pottery will also be the focus of my future research, and I will pay more attention to the production system of ordinary pottery to provide a more

detailed and credible discussion about the relationship between pottery production and social development.

Besides that, specialization in pottery production also played a crucial role in the gradual maturation process of the early Chinese state, the subsequent Shang Dynasty. In this study, only some of the cooking vessels from Yanshi were verified in terms of size, and other related attributes were not examined. This requires a comprehensive examination in future studies to understand the production of pottery in the Yanshi Shangcheng. And not only the Yanshi, but also several urban centers of the Shang dynasty existed after the Erlitou site, where the specialization of pottery production needs to be explored to answer the question: how did pottery production change in a more complex society, especially the maturation of the early state, and how were these changes specifically related to the complexity of the society. These are all questions that need to be further explored in my future research.

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Appendix

#1 RAW DATA of direct evidence

Table 1 The finding of “direct evidence” of pottery production in Taosi site

No.	Sample	Type	Period	Region	No.	Sample	Type	Period	Region
1	Y310	Kiln	Early	District 1	43	T370④A:7	Pad	Early	District 1
2	Y312	Kiln	Early	District 1	44	T421④E:17	Pad	Middle	District 4
3	Y313	Kiln	Early	District 1	45	H420:1	Pad	Middle	District 4
4	Y314	Kiln	Early	District 1	46	H401:4	Pad	Late	District 4
5	Y315	Kiln	Early	District 1	47	T1023F:16	Pad	Middle	District 1
6	99Y1	Kiln	Early	District 2	48	H420:12	Pad	Middle	District 4
7	99Y2	Kiln	Early	District 2	49	T431④B:30	Pad	Late	District 4
8	02Y1	Kiln	?	District 1	50	J401:59	Pad	Late	District 4
9	02Y2	Kiln	?	District 1	51	VC:02	Pad	Late	District 4
10	02Y3	Kiln	Early	District 1	52	H425:4	Pad	Late	District 4
11	02Y4	Kiln	?	District 1	53	Y403:6	Pad	Late	District 4
12	02Y5	Kiln	?	District 1	54	T423④A:5	Pad	Late	District 4
13	Y401	Kiln	Late	District 4	55	4C:03	Pad	?	District 4
14	Y402	Kiln	Late	District 4	56	T404④:46	Pad	Late	District 4
15	Y403	Kiln	Late	District 4	57	J401:68	Pad	Late	District 4
16	Y404	Kiln	Middle	District 4	58	J401:126	Pad	Late	District 4
17	Y405	Kiln	Middle	District 4	59	H401:8	Pad	Late	District 4
18	Y406	Kiln	Middle	District 4	60	T401④:25	Pad	Late	District 4
19	3Y1	Kiln	Middle	District 3	61	T404④:10	Pad	Late	District 4
20	3Y2	Kiln	Middle	District 3	62	H381:1	Mold	Early	District 1
21	3Y3	Kiln	Middle	District 3	63	4C:04	Mold	Late	District 4
22	3Y4	Kiln	Middle	District 3	64	4C:05	Mold	Late	District 4
23	3Y5	Kiln	Middle	District 3	65	H302:19	Mold	Late	District 1
24	3Y6	Kiln	Middle	District 3	66	J401:109	Mold	Late	District 4
25	3Y7	Kiln	Middle	District 3	67	J401:107	Mold	Late	District 4
26	3Y8	Kiln	Middle	District 3	68	J401:124	Mold	Late	District 4
27	3Y9	Kiln	Middle	District 3	69	T405(4)A:11	Mold	Late	District 4
28	3Y10	Kiln	Middle	District 3	70	H401:28	Mold	Late	District 4
29	H3409:1	Pad	Early	District 1	71	H365:21	Knife(pottery)	Early	District 1
30	2H4:6	Pad	Early	District 2	72	H303:95	Knife(pottery)	Early	District 1
31	2T1(3)D:30	Pad	Early	District 2	73	T423(4)A:6	Daggers- shape item	Late	District 4
32	H3443:14	Pad	Early	District 1	74	J401:26	Daggers- shape item	Late	District 4
33	T370(4)A:12	Pad	Early	District 1	75	J401:57	Daggers- shape item	Late	District 4

34	T311(4)A:14	Pad	Early	District 1	76	J402:28	knife(bone)	Late	District 4
35	H354 : 3	Pad	Early	District 1	77	H354:12	knife(bone)	Early	District 1
36	T406⑤:9	Pad	Early	District 4	78	H433:3	knife(bone)	Late	District 4
37	T4035:34	Pad	Middle	District 4	79	2T51(3)B:2	knife(bone)	Early	District 2
38	J403:7	Pad	Early	District 4	80	H303:3	knife(bone)	Late	District 1
39	J402:25	Pad	Early	District 4	81	H318:13	knife(bone)	Late	District 1
40	T404④:1	Pad	Late	District 4	82	H416:4	knife(bone)	Middle	District 4
41	T340④C:6	Pad	Early	District 1	83	H420:4	knife(bone)	Middle	District 4
42	2H4:43	Pad	Early	District 2	84	H319:7	awl(bone)	Middle	District 1

Table 2 The findings of direct evidence about pottery production in Erlitou site

Kilns	Samples	tools	Samples
	2004Y1	陶模(mold)	2004-1T6841(3):107
	2004Y2	陶垫(Pad)	2004-1T6841(3):20
	2005Y1	陶垫(Pad)	2004-1T7138(5):34
	2005Y3	陶垫(Pad)	204-1T6741(4):29
	2006Y1	陶垫(Pad)	2004H103:2
	2004Y4	陶垫(Pad)	2004H103:1
	2004Y5	陶垫(Pad)	2005H34:3
	2005Y6		
Wells	Samples		
	2004J1		
	2004J2		
	2004H438		
	2005H126		
	2005H133		
	2006H13		

2 clay data

Table 3 The chemical components percentage of clay from Taosi site

No	Context	Period	SiO ₂	Al ₂ O ₃	FeO	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂
1	M	early	64.49	15	0.43	5.31	3.29	2.17	1.88	2.25
2	M	early	64.43	16.57	0.67	5.91	1.13	2.28	2.09	1.88
3	M	early	62.74	16.41	0.92	4.88	1.35	2.48	1.75	1.88
4	M	early	64.19	15.61	0.78	5.7	2.01	1.67	2.08	2.23
5	M	early	60.84	19.15	0.78	3.75	2.12	1.42	2.35	2.64
6	M	early	70.22	14.8	2.44	3.47	0.82	0.92	1.44	1.55
7	M	early	66.05	15.26	1.55	5.13	1.04	1.04	1.99	2.18
8	H	Miao	64.95	16.13	0.34	5.58	0.33	1.33	2.2	2.64
9	H	Miao	69.18	16.48	0.9	6.04		0.9	2.6	2.6
10	H	Miao	64.69	17.31	1.4	5.44	1.14	1	2.44	2.55
11	H	Miao	64.27	14.68	1.18	5.79	3.18	1.44	2.43	2.24
12	H	Miao	64.5	14.55	2.66	3.93	3.64	1.46	2.22	2.25
13	H	early	66.04	17.26	0.89	5.41	0.41	0.72	2.44	1.9
14	H	early	69.84	16.23	1.72	5.28	0.32	0.81	2.33	2.55
15	H	early	69.2	16.23	0.35	6.28	0.16	0.91	2.29	2.48
16	H	early	67	18.02	2.09	3.82	1.14	1.11	2.48	1.44
17	H	early	67.07	18.82	0.44	5.76	0.81	1.11	2.38	1.24
18	H	early	68.16	17.62	0.71	5.33	0.97	1.41	2.32	1.59
19	H	early	68.44	17.64	3.71	1.49	0.65	1.01	2.43	1.78
20	H	early	65.21	17.64	0.69	6.64	0.16	1.44	2.06	1.09
21	H	early	66.54	17.16	0.3	6.29	0.16	1.13	2.23	1.24
22	H	early	66.13	17.61	1.55	4.85	0.16	0.61	2.41	1.39
23	H	early	68.34	17.92	3.59	3.76		0.2	2.37	1.07
24	H	late	65.94	17.05	2.58	4.39	2	0.26	2.87	1.37
25	H	late	67.14	16.48	2.6	3.96	1.13	0.9	2.72	1.32
26	H	late	69.37	15.95	2.05	4.21	1.94	0.8	2.47	1.38
27	H	late	65.24	19.07	2.73	3.09	1.45	0.5	2.69	1.27
28	H	late	67.02	17.38	3.17	2.53	1.94	0.1	2.69	1.38
29	H	late	67.67	15.96	2.83	3.21	1.78	0.2	2.44	1.27
30	H	late	65.98	15.88	0.9	5.45	2.13	0.1	2.62	1.41
31	H	late	65.98	16.88	0.2	7.07	2.66	0.1	2.49	1.3
32	H	late	58.81	17.2	3.72	2.86	5.14	2.99	2.71	1.52
33	H	Miao	66.45	14.81		5.67	1.51	1.36	2.63	1.26
34	O	modern	64.53	15.88		6.22	1.85	0.84	2.38	1.45
35	O	modern	51.93	10.82		4.33	11.66	3.38	2.1	1.92
36	O	modern	56.86	13.32		5.45	5.91	1.64	2.43	2.19
37	O	modern	65.44	15.02		5.93	1.48	0.92	2.35	1.44
38	O	modern	59.16	11.93		5.16	7.17	1.93	2.05	1.73

M: Burials; H: Pits; O: Ordinary soil

Early: early period of Taosi culture ;Late: late period of Taosi culture; Miao: Miaodigou culture; Modern: Modern time

Table 4 The ICP-AES result of chemical components percentage of clay from Erlitou site

Sample	period	Function	Location	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅
2002 V G10②	1	cooking	5	62.53	17.60	7.68	2.73	1.21	1.09	3.48	0.81	0.25
2002IX 采集	1	storage	9	66.94	17.15	7.04	2.06	1.55	0.80	2.49	0.84	0.25
2002 V G10②	1	cooking	5	60.90	18.30	8.47	2.87	1.34	1.05	3.71	0.82	0.36
2002 V G10②	1	storage	5	68.24	15.65	6.39	2.09	1.18	1.33	3.17	0.82	0.16
2002 V G10②	1	storage	5	62.92	18.18	8.14	2.82	1.35	0.99	3.59	0.87	0.23
2002 V G10②	1	storage	5	62.95	15.51	6.08	1.97	2.78	0.94	2.91	0.72	0.23
2002 V G10②	1	storage	5	62.90	17.89	8.41	2.65	1.33	1.03	3.34	0.85	0.31
2002 V G10②	1	storage	5	62.97	18.11	8.21	2.70	1.33	0.90	3.60	0.82	0.26
2002 V G10②	1	storage	5	61.85	17.71	8.02	2.64	1.69	1.01	3.50	0.81	0.30
2002 V G10②	1	storage	5	61.01	17.05	7.41	2.67	1.31	1.12	3.66	0.80	0.36
2002 V G10②	1	storage	5	63.86	17.43	7.47	2.45	1.25	1.05	3.36	0.82	0.35
2002 V G10②	1	storage	5	61.40	17.30	7.73	2.62	1.38	1.11	3.62	0.81	0.35
2002 V G10②	1	storage	5	60.37	17.76	8.36	2.67	2.39	1.02	3.40	0.83	0.27
2002 V G10②	1	cooking	5	63.93	17.63	7.88	2.62	1.24	1.10	3.33	0.83	0.23
2002 V G10②	1	cooking	5	63.60	17.76	8.02	2.67	1.27	1.00	3.37	0.84	0.25
2002 V G10②	1	storage	5	62.03	17.73	7.96	2.68	1.37	1.02	3.57	0.83	0.39
2002 V G10②	1	storage	5	62.47	17.93	8.17	2.76	1.29	1.03	3.51	0.84	0.26
2000 III H12	2	storage	3	61.51	16.43	7.68	2.51	1.54	1.11	3.42	0.79	0.76
2000 III H12	2	storage	3	61.34	16.54	7.87	2.56	1.95	1.00	3.35	0.78	0.65
2000 III H12	2	storage	3	61.74	16.06	7.40	2.37	1.87	1.07	3.27	0.79	0.81

2000 III H12	2	storage	3	61.92	15.96	7.39	2.45	1.75	1.10	3.32	0.70	0.73
2000 III H12	2	storage	3	61.68	16.35	7.39	2.47	1.82	1.18	3.46	0.76	0.81
2001 V T8⑤	2	serving	5	60.73	17.13	7.56	2.77	1.50	1.10	3.72	0.79	0.51
2001 V T8⑤	2	storage	5	63.04	16.15	7.22	2.49	1.30	1.14	3.37	0.79	0.34
2001 V T8⑤	2	storage	5	61.22	18.83	8.56	2.75	1.93	0.65	3.67	0.80	0.41
2001 V T8⑤	2	storage	5	62.86	17.77	8.16	2.71	1.35	1.00	3.49	0.85	0.31
2001 V T8⑤	2	storage	5	62.53	18.29	8.31	2.83	1.27	0.97	3.53	0.84	0.24
2001 V T8⑤	2	serving	5	62.70	18.20	8.27	2.79	1.25	0.99	3.54	0.82	0.24
2001 V T8⑤	2	storage	5	68.05	14.54	5.89	1.55	1.56	0.79	2.85	0.78	0.55
2001 V T8⑤	2	cooking	5	62.68	18.24	8.34	2.78	1.24	0.92	3.54	0.84	0.33
2001 V T3④	3	storage	5	64.48	16.48	7.07	2.30	1.56	1.12	3.24	0.79	0.49
2001 IV 采集	3	storage	4	66.27	15.09	6.33	2.05	1.37	1.08	2.91	0.71	0.52
2001 V T3④	3	storage	5	64.31	17.13	7.65	2.42	1.39	1.05	3.34	0.79	0.29
2000 III T4⑬	3	storage	3	63.69	17.85	8.05	2.66	1.27	0.95	3.39	0.81	0.17
2000 III T4⑬	3	storage	3	63.28	16.80	7.38	2.40	1.61	1.04	3.47	0.76	0.46
2000 III T4⑬	3	storage	3	63.14	17.70	8.00	2.60	1.38	0.90	3.53	0.80	0.41
2000 III T4⑬	3	storage	3	67.86	16.72	6.91	2.07	1.21	0.46	2.85	0.85	0.11
2000 III T4⑬	3	storage	3	67.51	16.39	6.81	2.25	1.32	1.08	3.02	0.77	0.16

2000 III T4⑯	3	storage	3	60.63	18.91	8.75	2.93	1.30	1.20	3.93	0.82	0.29
2000 III T4⑯	3	serving	3	61.19	16.34	7.31	2.51	1.91	1.10	3.31	0.79	0.57
2000 III T4⑯	3	storage	3	67.40	15.52	6.23	2.11	1.35	1.28	3.08	0.76	0.27
2000 III T4⑯	3	cooking	3	62.91	17.15	7.72	2.43	1.29	1.16	3.37	0.81	0.32
2000 III T4⑩	4	storage	3	65.83	16.77	7.14	2.36	1.52	1.12	3.27	0.80	0.22
2002 V T11④	4	storage	5	70.60	15.66	6.22	1.65	1.14	0.68	2.51	0.82	0.09
2000 III T4⑩	4	storage	3	67.61	14.86	6.26	2.01	1.60	1.46	2.88	0.78	0.40
2000 III T4⑩	4	storage	3	59.62	17.79	8.41	2.82	1.80	0.74	3.33	0.79	0.46
2002 V T11④	4	storage	5	67.12	16.16	6.91	2.26	1.33	1.23	3.03	0.80	0.18
2002 V T11④	4	storage	5	61.68	16.13	6.80	2.39	2.14	1.04	2.92	0.76	0.35
2002 V T11④	4	storage	5	65.98	16.46	7.17	2.35	1.52	1.21	3.19	0.79	0.20
2002 V T11④	4	storage	5	63.78	17.44	7.87	2.70	1.36	1.07	3.47	0.82	0.23
2000 III T3⑤	4	storage	3	65.52	16.84	7.21	2.28	1.40	1.10	3.33	0.85	0.33
2000 III T3⑤	4	storage	3	63.69	17.84	7.83	2.60	1.32	1.14	3.38	0.82	0.26
2000 III T3⑤	4	storage	3	62.34	17.73	7.88	2.55	1.38	1.10	3.46	0.81	0.33
2000 III T3⑤	4	storage	3	65.92	17.11	7.04	2.31	1.34	1.13	3.09	0.81	0.20

2000 III T3⑤	4	storage	3	61.80	18.29	8.07	2.62	1.44	1.05	3.66	0.82	0.50
2000 III T3⑤	4	storage	3	64.56	15.63	6.58	2.27	1.45	1.38	3.33	0.74	0.26
2000 III T3⑤	4	storage	3	65.80	16.66	7.25	2.37	1.41	1.15	3.36	0.83	0.22
2000 III T3⑤	4	storage	3	64.95	17.23	7.52	2.48	1.31	1.37	3.30	0.79	0.20
2000 III T3⑤	4	storage	3	66.33	16.42	6.92	2.27	1.43	1.37	3.13	0.80	0.22
2000 III T3⑤	4	storage	3	63.26	16.38	7.39	2.63	1.60	1.24	3.36	0.85	0.32
2000 III T3⑤	4	storage	3	65.10	17.26	7.50	2.43	1.27	1.24	3.16	0.79	0.22
2000 III T3⑤	4	storage	3	63.81	16.48	7.21	2.33	1.54	1.18	3.26	0.79	0.40
2000 III T3⑤	4	storage	3	64.51	16.68	7.40	2.46	1.48	1.31	3.21	0.82	0.34

Table 5 The EDXRF result of chemical components percentage of clay from Erlitou site

#	Period	function	出土单位	location	type	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	CaO	MgO	K ₂ O	Na ₂ O
1	2	storage	2002 V G10①	5	o	67.14	17.93	6.04	0.47	1.81	2.46	3.08	0.07
2	2	storage	2002 V G10①	5	o	66.25	18.87	5.09	0.49	1.41	2.98	2.90	1.01
3	2	storage	2002 V G10①	5	o	63.55	19.40	5.72	0.52	1.90	3.47	3.69	0.74
4	2	cooking	2002 V G10①	5	o	65.76	19.48	5.43	0.52	1.60	2.81	3.12	0.29
5	2	storage	2002 V G10①	5	o	64.21	18.63	5.92	0.51	1.50	3.31	3.74	1.18
6	2	storage	2001 V H8	5	o	64.05	17.89	6.59	0.53	1.64	3.22	4.27	0.82
7	2	cooking	2001 V H8	5	o	67.23	16.60	5.34	0.58	1.29	3.59	3.01	1.36
8	2	cooking	2001 V H8	5	o	72.21	14.88	4.94	0.36	1.81	2.07	2.01	0.71
9	2	serving	2001 V H8	5	o	63.50	18.59	6.08	0.57	1.72	3.76	3.88	0.90
10	2	storage	2002 V T14⑤	5	o	66.67	15.13	6.31	0.51	4.56	2.43	2.79	0.60
11	3	storage	2001 V T4D2HC	5	o	65.37	17.99	6.06	0.50	1.59	3.10	3.42	0.97
12	3	cooking	2001 V T4D2HC	5	o	65.73	17.74	6.01	0.52	1.40	2.83	4.03	0.74
13	3	cooking	2001 V T4D2HC	5	o	67.94	16.75	6.08	0.45	1.42	2.50	2.74	1.12

14	3	serving	2001 V T4D2HC	5	o	67.16	16.29	5.39	0.50	2.14	2.73	3.36	1.43
15	3	storage	2001 V T4D2HC	5	o	64.62	19.69	6.68	0.48	1.34	2.37	2.85	0.97
16	4	storage	2002 V H112	5	o	62.35	18.81	7.11	0.55	1.41	3.86	4.33	0.57
17	4	storage	2002 V H112	5	o	61.94	18.79	7.03	0.60	1.33	3.77	4.17	1.36
18	4	storage	2002 V H112	5	o	67.71	17.59	5.74	0.52	1.55	2.55	3.07	0.27
19	4	storage	2002 V T27④	5	o	64.74	17.30	6.67	0.53	1.34	3.36	3.42	1.64
20	4	serving	2002 V T27④	5	o	63.12	17.73	6.77	0.51	2.39	3.63	3.80	1.05
21	2	drinking	2002 V G10①	5	w	66.35	21.25	2.48	0.52	4.02	1.08	2.71	0.59
22	2	drinking	2003 V T32⑤	5	w	68.97	24.66	2.30	0.86	0.58	0.43	0.90	0.30
23	2	storage	2003 V T32⑤	5	w	63.50	26.68	3.65	0.72	0.70	0.91	2.53	0.27
24	2	drinking	2001 V T6⑤	5	w	63.61	27.86	3.13	0.71	0.98	0.67	1.71	0.33
25	2	drinking	2001 V T6⑤	5	w	65.61	24.33	3.75	0.59	0.57	0.92	2.82	0.40
26	2	storage	2004 V H275	5	w	60.16	29.16	3.95	0.70	1.37	1.04	2.02	0.61

27	4	drinking	2003 V H181	5	w	64.81	23.62	4.48	0.71	0.96	0.94	2.72	0.77
28	2	drinking	2003 V T32⑤	5	w	60.29	30.11	1.97	0.62	2.29	0.95	2.27	0.49
29	2	storage	2001 V T5⑤	5	w	65.93	24.35	3.14	0.56	1.03	1.08	2.69	0.21
30	4	drinking	2004 V T85④	5	w	68.85	21.92	3.28	0.52	0.84	1.02	2.39	0.18
31	3	drinking	2002 V T20④	5	w	67.07	20.78	5.52	0.56	0.95	1.22	2.65	0.26
32	4	drinking	2000 III T2⑤	3	w	70.27	21.80	2.48	0.53	1.10	0.95	L.81	0.07
33	2	drinking	2003 V T32⑤	5	p	75.32	16.38	2.45	0.60	0.27	2.13	1.64	0.21
34	3	drinking	2001 V T5④	5	w	67.42	20.77	5.20	0.58	1.08	1.24	2.46	0.26
35	2	storage	2003 V T32⑤	5	w	65.09	25.21	2.71	0.63	0.87	1.17	2.95	0.37
36	2	storage	2001 V T5⑤	5	w	59.89	29.91	3.91	0.76	1.19	0.94	2.17	0.23
37	2	drinking	2003 V T32⑤	5	w	67.65	23.74	2.73	0.51	0.72	1.09	2.48	0.07
38	4	drinking	2002 V T29D6L	5	p	72.53	17.69	4.28	0.61	0.22	0.82	2.12	0.74
39	2	drinking	2003 V H202	5	p	67.92	22.04	3.52	0.65	0.68	1.36	2.76	0.07

40	2	drinking	2001 V H8	5	p	64.88	24.52	4.11	0.59	1.17	0.76	2.70	0.27
41	2	drinking	2001 V M1	5	p	72.50	18.59	2.95	0.89	0.36	1.21	2.04	0.46
42	2	drinking	2002 V T14⑥	5	p	67.93	22.30	4.03	0.78	0.19	1.17	2.40	0.22
43	2	storage	2002 V T32⑤	5	w	65.20	26.06	2.62	0.61	0.47	1.18	2.54	0.31

Type O: Ordinary pottery; P: Porcelain; W: White pottery;

Table 6 Fingerprint chemical component of white pottery

	Li	Be	Sc	Ti	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Sn	Cs	Ba
BIR-1	2.960	0.113	44.7	5702	321	409	51.54	163.3	116.2	n.d.	15.59	0.18	107.18	14.69	13.98	0.528	0.815	0.005	6.474
BCR-2	9.648	2.478	34.6	14067	425	16.47	37.56	11.87	9.13	n.d.	21.78	46.8	340.9	33.8	178.7	12.31	2.302	1.147	667
JB-2	8.16	0.32	55.7	6918	569	25.71	37.28	20.46	222.6	121.5	16.42	6.25	175.3	21.9	45.7	0.469	0.566	0.806	223
NW N112:1	25.6	2.156	18.32	5462	90.1	89.2	8.46	16.41	14.22	37.6	29.1	90.1	47.4	37.5	254	19.10	3.765	5.83	431
NW H150:1	14.5	2.994	16.34	5125	108.2	76.8	4.67	9.94	10.56	37.0	25.0	58.3	43.1	27.0	442	16.84	3.081	2.75	341
NW H180:1	33.1	3.541	22.01	5039	145.1	83.4	4.97	9.71	36.84	20.0	31.1	103.7	190.1	20.1	279	16.48	3.836	8.05	972
NW H251-1	56.4	2.301	16.34	4789	101.6	88.0	7.88	14.85	13.56	30.6	26.3	64.0	83.5	19.8	280	17.34	3.687	2.93	845
NW J2-1	19.6	2.859	19.71	4892	17.3	94.8	12.41	13.57	19.58	30.9	32.2	80.6	27.5	14.0	258	18.20	4.189	3.21	485
NW 1	57.7	3.461	20.70	5407	134.1	91.1	9.41	24.41	47.67	33.3	31.1	49.3	85.2	22.3	261	12.53	3.384	4.00	563
NW U-1	23.4	1.967	15.73	3626	98.0	80.9	8.97	7.98	8.47	n.d.	26.1	64.0	35.3	15.3	230	17.55	3.190	2.67	331
NW U-2	22.2	2.146	16.25	3841	104.8	84.3	9.47	5.70	7.34	n.d.	27.7	66.8	34.2	15.3	246	18.78	3.453	2.82	371
NW U-3	23.7	2.082	16.55	3905	97.1	84.3	11.08	13.63	11.00	n.d.	27.9	70.0	30.6	15.7	242	18.65	3.561	3.20	358
ELT IV-3	38.6	2.699	19.40	5365	157.4	102.1	11.50	26.13	21.31	59.4	29.0	130.1	197.4	37.7	240	22.91	4.800	9.85	619

ELT IV-4	37.86	3.198	17.21	5209	156.2	95.5	15.29	35.43	17.02	79.7	25.5	105.5	249.2	38.3	296	21.97	4.840	11.67	414
ELT IV-5	39.1	2.985	18.79	6019	122.2	81.2	7.78	14.74	23.84	33.3	30.5	81.5	73.2	18.5	312	21.74	4.604	4.604	485
ELT IV-6	43.6	3.780	18.29	5536	151.7	93.9	13.98	28.70	12.57	60.7	29.2	119.0	415.9	42.2	292	23.92	5.357	13.86	381
HUIZ -1	206.0	3.226	41.40	7393	160.0	177.0	30.74	65.33	8.01	45.9	41.0	107.9	367.9	41.2	446	37.61	6.316	12.58	488
HUIZ -2	38.5	2.817	18.16	4544	243.8	121.8	3.42	27.45	10.04	25.8	23.7	107.9	236.1	35.0	177	17.40	3.790	13.77	289
HUIZ -3	82.4	2.239	26.22	5298	150.4	160.0	3.12	17.02	6.07	12.2	26.6	96.8	101.1	28.6	279	21.17	4.082	9.97	254
HUIZ -4	34.8	3.163	19.52	4909	255.7	128.9	3.52	30.33	14.52	59.3	25.6	107.0	232.6	35.0	188	17.71	4.571	14.34	300
HUIZ -5	30.2	2.441	17.06	4956	93.7	73.3	4.17	11.13	5.91	n.d.	28.2	78.3	65.8	18.8	229	19.08	3.202	4.09	365
HUIZ -6	133.7	1.632	14.50	4469	109.5	110.6	10.21	44.65	7.93	n.d.	29.2	61.1	104.4	24.7	302	29.80	5.522	8.29	161
HUIZ -7	37.3	2.638	15.10	4285	106.2	89.0	9.22	13.53	28.25	n.d.	20.0	125.9	73.9	27.1	197	18.18	3.233	7.31	541
HUIZ -11	207.6	3.019	32.24	6515	128.6	132.7	11.63	60.98	13.27	51.8	33.8	62.6	109.5	28.8	338	28.88	6.362	8.92	180
HUIZ -12	40.4	2.226	19.59	4115	199.2	109.3	20.53	39.19	12.78	65.5	21.8	113.7	146.7	23.2	175	15.05	4.138	10.10	522

HUIZ-13	38.4	2.284	14.84	5839	105.2	69.2	5.24	10.13	14.91	22.1	27.3	77.9	58.0	21.2	348	21.43	4.125	3.92	365
HUIZ-14	150.2	2.568	33.10	6397	135.4	145.5	18.44	45.49	11.77	49.4	33.2	87.5	123.2	30.3	342	28.02	6.054	10.58	272
HANZ-1	38.6	1.968	0.00	4460	206.2	132.5	4.84	15.98	9.72	23.4	25.4	128.3	136.2	24.1	201	7.48	3.721	12.89	433
HANZ-2	11.9	0.884	0.00	1623	28.4	28.5	4.16	5.70	8.71	11.4	11.5	72.5	57.3	22.3	115	5.89	0.969	2.75	359
NW U-8	23.7	2.068	16.67	4193	94.2	89.2	8.05	14.67	6.74	n.d.	27.3	72.0	33.2	15.9	262	12.85	3.493	3.10	346
NW U-10	29.1	2.421	17.31	3910	90.1	90.2	7.06	12.61	14.63	n.d.	27.9	54.1	41.3	17.3	285	21.46	4.591	3.41	356
NW U-11	23.8	1.864	15.48	3845	92.0	84.3	8.61	9.12	10.66	n.d.	27.3	72.2	35.4	17.9	208	19.12	3.420	3.39	364
NW U-12	25.7	2.215	18.76	4479	110.9	98.6	10.60	6.69	11.20	n.d.	31.8	79.9	38.3	17.7	275	21.35	4.004	3.63	449
NW U-13	22.6	2.523	18.60	3628	97.3	86.8	21.28	11.03	14.81	n.d.	30.8	73.0	32.0	14.3	229	18.03	3.754	2.93	482
NW SOIL 1	21.5	1.282	7.73	1427	35.9	45.0	5.87	20.30	13.80	23.1	8.9	57.1	174.8	21.4	136	4.14	1.008	4.79	319
NW SOIL 2	5.2	0.213	2.11	397	8.1	7.5	2.73	13.89	4.18	3.6	1.9	10.4	355.0	3.7	22	1.37	0.212	0.90	148
ELT II-1	47.0	4.544	19.67	4894	235.8	161.6	13.62	38.58	17.67	112.3	24.5	103.1	232.8	37.9	205	18.06	4.171	15.70	294

ELT II-2	32.5	2.716	12.71	3293	93.8	92.5	14.26	35.66	25.84	81.8	15.2	105.9	143.3	24.3	153	12.74	2.675	7.34	780
ELT II-3	55.0	4.146	20.33	5086	221.8	187.5	11.24	39.13	19.29	71.0	24.9	129.5	239.3	41.4	203	17.98	4.252	15.67	305
ELT II-4	90.0	2.838	13.80	6126	314.8	149.1	2.86	39.92	6.89	16.4	30.5	109.1	83.8	30.3	332	25.37	5.175	12.96	327
ELT II-5	62.0	2.400	11.40	5032	242.0	112.0	2.12	28.53	5.83	23.9	25.9	110.9	80.8	27.6	272	21.22	4.187	12.65	268
ELT II-6	71.7	2.283	19.72	5926	283.4	116.9	2.72	36.22	5.43	24.9	32.0	116.2	89.1	31.9	326	24.89	6.231	14.49	326
ELT II-6	41.7	2.953	23.49	5629	157.9	86.8	6.39	19.49	31.63	34.4	32.7	55.4	73.0	16.2	298	18.71	4.467	4.28	310
ELT II-7	76.3	1.966	20.36	5743	200.5	123.3	9.20	30.92	12.44	86.9	25.7	87.4	182.1	27.0	273	22.09	4.925	9.01	563
ELT II-12	42.2	2.352	17.56	5185	139.8	109.5	7.59	23.18	8.77	29.6	27.1	105.0	88.3	24.4	200	19.33	5.108	16.10	352
ELT II-14	58.3	2.704	19.12	8193	153.8	82.0	9.55	14.38	17.74	31.5	31.4	74.7	70.8	26.1	503	28.30	5.364	3.45	388
ELT II-16	105.1	2.355	29.43	5804	149.0	141.8	5.13	34.67	14.14	57.7	32.7	91.3	97.5	30.3	318	25.26	5.967	10.03	217
ELT III-1	40.2	3.104	14.67	4325	142.4	84.2	15.25	32.76	3.74	13.3	26.8	128.5	484.6	38.5	277	25.41	4.172	11.22	315
ELT III-2	30.0	3.366	32.18	7661	147.9	53.0	5.63	14.63	10.08	18.4	36.3	35.9	97.9	34.6	339	14.17	2.964	2.54	300

ELT III-3	39.6	3.876	18.30	5658	166.5	95.2	4.75	33.96	12.56	55.3	28.6	115.4	254.6	38.6	306	24.51	5.325	12.42	351
ELT III-4	36.0	1.586	15.65	5576	183.6	124.8	1.69	9.61	6.96	27.5	24.7	116.9	93.9	20.9	198	19.57	4.735	11.28	342
ELT III-5	38.0	2.942	16.62	4947	170.0	120.9	5.55	27.89	21.78	66.3	23.9	85.6	204.0	34.9	217	17.69	4.351	10.97	320
ELT III-6	38.2	2.940	17.33	4982	171.7	122.1	5.00	28.70	21.06	60.6	24.0	82.4	212.4	33.9	220	17.95	4.353	10.91	306
ELT IV-1	49.1	2.736	21.39	4335	174.5	108.8	9.22	22.34	13.58	53.6	23.5	64.7	115.3	24.2	259	20.91	3.609	8.49	314
ELT IV-2	33.0	1.609	16.63	4241	160.2	96.5	3.548	19.93	7.58	6.7	23.6	90.2	104.8	20.0	182	17.08	4.310	12.30	239

#3 The raw data of GMM analysis

Table 7 PC scores of Cooking Jia from Taosi site in GMM analysis

#	Sample	Period	Context	PC1	PC2
1	M3015:26	early	M1	0.1885	0.0738
2	M2001:58	early	M1	0.1806	0.2546
3	M2014:7	early	M2	0.0299	0.0186
4	M2180:15	early	M2	-0.0020	0.0110
5	M3015:26	early	M1	0.1791	-0.0166
6	M3016:13	early	M1	0.4510	0.1164
7	M2001:59	early	M1	-0.1193	0.1151
8	M3015:30	early	M1	-0.1900	0.1354
9	M3002:32	early	M1	-0.2115	0.1619
10	M1111:6	early	M2	0.1230	0.0588
11	M2035:10	early	M2	0.3854	-0.1371
12	M2112:7	early	M2	-0.2614	-0.1322
13	M2115:9	early	M2	0.0528	-0.0713
14	M2043:9	early	M2	0.6043	-0.0821
15	M2172:17	early	M2	0.1928	-0.2293
16	M2168:6	early	M2	0.5257	-0.1827
17	M2027:8	early	M2	0.5295	-0.0737
18	M2103:16	early	M2	0.4401	-0.1360
19	M2014:10	early	M2	0.0888	-0.0432
20	M2092:2	early	M2	0.4620	0.1170
21	M1111:4	early	M2	-0.1082	0.1338
22	M2103:9	early	M2	-0.2042	0.0897
23	M2035:6	early	M2	-0.1856	0.0825
24	M2180:8	early	M2	-0.6464	-0.0064
25	M2079:9	early	M2	-0.2913	0.0621
26	M3002:47	early	M1	-0.2814	0.2489
27	T310(4):14	early	1B	0.2731	0.1975
28	H325:7	early	1B	-0.0610	0.1651
29	H439:3	early	D4	-0.1122	0.2998
30	IIH102:29	early	D2	-0.3362	0.2723
31	H3421:3	early	D2	-0.0871	0.1642
32	IIT1(3)B:10	early	D2	0.5169	0.0684
33	T399(3)B:5	middle	D1north	-0.2689	-0.1609
34	H3421: 5	early	D1north	0.1261	0.1356
35	H303:13	late	D1north	0.1981	-0.0979

M1: top elite burials; M2: secondary elite burials; D: district.

Table 8 PC scores of Storage Guan from Taosi site in GMM analysis

#	Sample	Period	Context	PC1	PC2	Decoration
1	H393:1	early	D1north	-0.0127	-0.0183	A
2	I1H4:21	early	2	0.0562	0.0075	A
3	I1H4:24	early	2	0.0462	0.0065	A
4	J402:35	early	4	0.0542	0.0085	A
5	I1IC:03	early	D1north	0.0462	0.0642	A
6	T431 (4) E:31	early	4	0.0798	0.0312	A
7	T330(4)B:9	late	D1north	-0.0988	0.1259	A
8	H376:23	late	D1north	0.0254	0.0732	A
9	J401:108	middle	4	0.0173	0.1326	A
10	M2035:16	early	M2	-0.0197	-0.0201	A
11	M2095 : 6	early	M2	-0.0817	-0.0348	A
12	M2180:16	early	M2	-0.0604	-0.0541	B2
13	M2169:13	early	M2	0.0016	-0.0278	C
14	M2014:2	early	M2	0.0166	-0.0291	C
15	M2092:9	early	M2	-0.0079	-0.0181	C
16	M2092:10	early	M2	0.0347	-0.0049	C
17	M3072:4	early	M1	0.0771	-0.0384	C
18	M3073:20	early	M1	0.0967	0.0548	A
19	M2001:44	early	M1	0.0632	0.0005	C
21	M2001:68	early	M1	0.0921	0.0144	C
22	M2001:69	early	M1	0.1184	0.0133	C
23	M2035:17	early	M2	-0.0064	-0.0430	A
24	M2112:5	early	M2	-0.0202	-0.0229	C
25	M2168:16	early	M2	-0.0268	-0.0389	C
26	M2095:5	early	M2	-0.0144	-0.0431	C
27	M2172:18	early	M2	-0.0012	-0.0440	C
28	M2172:19	early	M2	0.0270	-0.0047	C
29	M2103:14	early	M2	-0.0099	-0.0483	C
30	T2103(3)A:1	early	M2	0.0208	-0.0161	C
31	M3016:6	early	M1	0.0213	-0.0531	C
33	M3016:7	early	M1	0.0139	-0.0308	C
34	M3015:38	early	M1	0.0449	-0.0557	C
35	M3015:58	early	M1	0.1268	-0.0421	C
36	M3015:59	early	M1	0.1427	-0.0171	C
37	M3015:27	early	M1	0.1650	-0.0063	C
38	M3002:8	early	M1	0.0766	-0.0377	C
39	M3002:54	early	M1	0.0854	-0.0198	A
40	M3002:9	early	M1	0.0224	-0.0225	A
41	M2103:29	early	M2	-0.0651	-0.0100	A
42	M2168:25	early	M2	-0.0573	-0.0224	A
43	M2168:23	early	M2	-0.1275	-0.0029	A

44	M2168:20	early	M2	-0.0148	0.0015	C
45	M2112:1	early	M2	-0.1213	-0.0532	A
46	M2095:4	early	M2	-0.0303	0.0160	A
47	M2079:7	early	M2	-0.0807	-0.0219	D
48	M2079:8	early	M2	-0.0901	-0.0348	D
49	M2079:12	early	M2	-0.0565	0.0046	C
50	M2180:5	early	M2	-0.0878	0.0031	B2
51	M2035:11	early	M2	-0.1135	0.0416	A
52	M3016:5	early	M1	-0.0016	0.0751	C
53	M2103:13	early	M2	-0.1267	-0.0487	C
54	M2172:16	early	M2	-0.0850	-0.0040	C

M1: top elite burials; M2: secondary elite burials; D: district.

Table 9 PC scores of Serving Dou from Taosi site in GMM analysis

#	Sample	Period	Context	PC1	PC2	Decoration
1	IH102:66	early	D2	-0.30722	-0.1073	A
2	J401:132	late	D4	-0.38887	0.10376	A
3	T310(3)B:15	early	D1 north	-0.14306	-0.012826	A
4	H374:9	early	D1 north	0.0959	-0.0145	A
5	IIT1(3)C:34	early	D2	0.12657	0.07726	A
6	H3403:12	late	D1 north	-0.18342	0.0303	A
7	H301:3	late	D1 north	-0.13724	0.12262	A
8	H310:28	late	D1 north	-0.32951	-0.06921	A
10	M2168:37	early	M2	-0.00405	0.12975	B1
11	M2172:12	early	M2	-0.09031	-0.02508	B2
13	M2180:7	early	M2	-0.0721	0.00294	B2
14	M2095:2	early	M2	0.0003	-0.07784	A
15	M2095:3	early	M2	0.09249	-0.01673	A
16	M2043:2	early	M2	0.03544	0.0599	B1
17	M2172:14	early	M2	0.03074	0.08619	B2
18	M2168:30	early	M2	0.15176	-0.00069	B1
19	M2168:31	early	M2	0.10354	0.02212	B1
20	M2168:36	early	M2	0.13817	-0.01701	B1
21	M2103:18	early	M2	0.08998	-0.07735	B1
22	M2035:19	early	M2	-0.04713	0.085991	B1
23	M2079:1	early	M2	0.10378	-0.08497	B2
24	M2079:2	early	M2	0.04693	-0.04493	B2
25	M2079:3	early	M2	-0.05872	-0.05555	B2
26	M2092:12	early	M2	0.09469	-0.07738	B2
27	M2092:14	early	M2	0.04957	-0.08406	B2
28	M2001:37	early	M1	0.19258	-0.23838	B2
29	M2001:38	early	M1	0.27999	-0.12572	B2
30	M2001:35	early	M1	0.20738	-0.24167	B2
31	M2001:40	early	M1	0.38562	-0.1325	B2
32	M2092:13	early	M2	0.05465	0.00952	B2
33	M2043:8	early	M2	-0.14763	-0.01217	B2
34	M3072:5	early	M1	0.14138	-0.0033	B1
35	M3073:12	early	M1	-0.03906	-0.0587	B2
36	M3073:13	early	M1	-0.08173	-0.00643	B2
37	M2172:11	early	M2	-0.06841	-0.01052	B2
38	IIF10:1	late	D2	-0.38818	0.09129	A
39	H6:37	late	D1 middle	-0.23156	0.10672	A

Table 10 PC scores of Cooking Li from the Taosi site in GMM analysis

#	Sample	Context	Period	PC1	PC2
1	IIIC:02	D1 north	middle	0.0441	0.1169
2	H301:8	D1 north	late	-0.0473	0.0795
3	H301:6	D1 north	late	-0.1365	-0.0221
4	H303:12	D1 north	late	-0.0918	-0.0361
5	H3403:6	D1 north	late	-0.0811	-0.0097
6	T399(3)A:6	D1 north	late	-0.1211	0.0267
7	H3421:6	D1 north	middle	0.1353	0.1372
8	T355(3)1B:32	D1 north	middle	0.0353	0.0318
9	H365:38	D1 north	middle	0.0633	0.0167
10	T421(4)D:23	D4	middle	0.0805	0.0376
11	T404(4):11	D4	late	0.0689	-0.0468
12	H376:28	D1 north	late	0.1024	-0.0553
13	H425:40	D4	late	0.0276	-0.0811
14	H302:29	D1 north	late	0.0232	0.0024
15	H425:41	D4	late	0.0335	-0.0545
16	T406 (4) F:11	D4	middle	0.029	-0.0169
17	H321:1	D1 north	middle	0.0362	0.0105
18	H365:7	D1 north	middle	0.1203	0.1023
19	H408:2	D4	middle	0.0701	-0.07
20	H430:5	D4	middle	0.0273	-0.0116
21	H302:24	D1 north	late	0.0291	-0.063
22	H376:29	D1 north	late	0.0306	-0.096
23	T403(4)C:49	D4	late	0.0791	-0.0165
24	H401:22	D4	late	0.0145	-0.0921
25	J401:112	D4	late	0.0534	-0.0015
26	T352(3)A:12	D1 north	late	-0.0307	-0.0194
27	99 2H22:9	D2	late	0.0653	-0.0035
28	99 2H22:12	D2	late	-0.0041	0.0219
29	99 2H22:4	D2	late	0.0848	0.0349
30	02H6:36	D1 middle	late	-0.0809	-0.0053
31	02T5126(3):3	D1 middle	late	0.0195	0.0418

Table 11 PC scores of Cooking jars with deep abdomen from Erlitou site in GMM analysis

#	Sample	Phase	Context	PC1	PC2
1	2002-5G10(1):17	2	P	-0.0477	-0.0086
2	2002-5G10(1):21	2	P	0.1043	0.0172
3	2002-5H57:4	2	P	0.2009	0.0084
4	2003-5H211:2	2	P	-0.0565	0.0025
5	2003-5H211:16	2	P	0.1664	-0.0136
6	2001-5H28:22	2	P	-0.0216	-0.0050
7	2001-5H28:19	2	P	-0.0148	0.0068
8	2001-5H28:21	2	P	0.0073	-0.0172
9	2001-5H28:20	2	P	0.0255	-0.0065
10	2001-5H44:11	2	P	-0.0094	-0.0321
11	2001-5H45:12	2	P	-0.0809	-0.0020
12	2002-5H92:6	3	P	0.0129	-0.0137
13	2002-5H92:7	3	P	-0.0200	-0.0081
14	2001-5H22:5	3	P	-0.0349	0.0104
15	2002-5H143 : 1	3	P	-0.0726	-0.0067
16	2002-5H112:16	4late	P	0.0174	0.0278
17	2002-5H147:11	4late	P	0.0104	0.0038
18	2001-5H272:7	4late	P	-0.0190	0.0130
19	2001-5H272:8	4late	P	-0.0004	0.0318
20	2003-5H218:3	4late	P	-0.0509	0.0073
21	2H216:11	1	C	0.1214	0.0018
22	5H110:10	2	P	-0.0465	-0.0090
23	4T7(5)B:11	2	P	0.0067	0.0042
24	4T3(7):11	2	W	-0.0308	-0.0264
25	2H216:13	1	C	0.0289	-0.0018
26	2·5H103:11	1	P	-0.0011	-0.0004
27	4H43:16	3	W	-0.0101	-0.0050
28	4T24(4)D:14	3	W	-0.0057	-0.0166
29	4T24(4)D:11	3	W	0.0355	0.0232
30	4H57:14	3	W	-0.0104	0.0008
31	7H53:12	1	P	0.0798	0.0131
32	5H87:15	4late	P	-0.0238	0.0133
33	5T12B(3)B:12	4late	P	0.0312	0.0209
34	5T2EH:11	4	P	-0.0070	0.0067
35	6M9 上:1	4	C	0.1058	0.0152
36	5H53:23	4late	P	-0.0457	-0.0379
37	5H53:11	4late	P	-0.0391	0.0115
38	5H83:26	4late	P	-0.0299	0.0131
39	5H53:12	4late	P	-0.0612	-0.0286
40	82YL5T15(9D):1	1	P	0.0374	0.0177

41	89YL6H101:1	3	C	-0.0526	-0.0056
42	80YL4T2(5):2	4	W	0.0199	-0.0020
43	81YL5H1:2	4	P	-0.1002	-0.0047
44	91YL4T2(5):1	4	W	0.0739	-0.0395
45	80YL3H8:2	4late	C	0.0359	0.0208
46	85YL5H27:4	4late	P	-0.0084	0.0033
47	85YL5T7(3A):3	4late	P	0.0519	0.0382
48	86YL6H18:3	1	C	0.0665	0.0395
49	85YL5H5:3	4late	P	0.0073	-0.0193
50	81YL3H21:1	2	C	0.0139	-0.0424
51	86YL6H26:1	2	C	0.0067	-0.0423
52	87YL4H1:1	2	W	0.0535	-0.0018
53	83YL4T16(3):1	2	W	0.0558	0.0061
54	82YL9H7:1	3	C	-0.0057	0.0367
55	83YL4H50:3	3	W	0.0140	0.0050
56	3T22(4):1	3	C	-0.0263	0.0058
57	3H23:2	4late	C	0.0640	0.0217
58	3H23:23	4late	C	-0.1012	0.0126
59	9H15:1	1	C	-0.0459	-0.0022
60	3H19:3	2	C	-0.0466	-0.0086

*Context P: Palace area; W: Workshop area; C: Commoner area(area rather than palace and workshop area)

*Phase 4: Phase 4 early stage; 4 late: Phase 4 late stage.

Table 12 PC scores of Cooking Li from Erlitou site in GMM analysis

#	Sample	Period	Context	PC1	PC2
1	4H57:98	3	W	-0.0895	0.0226
2	4H57:96	3	W	-0.2031	-0.0086
3	4H57:97	3	W	-0.0406	-0.0494
4	9M9:1	3	C	-0.0950	0.0537
5	9H30:1	3	C	-0.0865	0.0247
6	3T22(3):1	3	C	0.0682	-0.0055
7	3·5H240:59	3	C	0.2439	-0.0610
8	5H101:11	4 late	P	0.1202	-0.0064
9	2·5T126(3):11	4	P	0.0038	0.0383
10	5H57:10	4 late	P	0.0677	0.0207
11	5H101:12	4 late	P	0.0487	-0.0481
12	5H83:30	4 late	P	-0.0863	0.0268
13	5H83:18	4 late	P	-0.0300	0.0313
14	5T214(3)B:11	4	P	0.1453	0.0563
15	5H54:12	4	P	-0.1316	0.0289
16	5H83:13	4late	P	0.0941	-0.0090
17	4H93:11	4	W	0.0541	-0.0083
18	2000-3H24:5	4 late	C	0.0911	0.0514
19	5H53:13	4 late	P	0.0752	0.0518
20	2000-3H24:112	4 late	C	0.1065	-0.0145
21	5H53:22	4 late	P	0.1186	0.0605
22	2002-5H112:20	4 late	P	0.1028	-0.0044
23	2001-5H272:10	4 late	P	-0.0125	-0.0591
24	2003-5H228 : 10	4 late	P	-0.0399	0.0444
25	2002-5H112:52	4 late	P	0.0257	-0.0031
26	2001-5H272:12	4 late	P	-0.0873	0.0232
27	2002-5H87:15	4 late	P	0.0568	0.0227
28	3H8:5	4 late	C	-0.0102	-0.0287
29	81YL4M2:1	4	W	-0.0206	-0.0625
30	84YL4H122:1	4	W	-0.0438	-0.0407
31	82YL9M9:1	3	C	-0.2040	-0.0298
32	82YL8H9:1	4	C	-0.1067	-0.0426
33	86YL4T5(3B):1	4	W	-0.0447	-0.0354
34	92YL9H111:4	4	C	0.0170	0.0227
35	86YL6H5:4	4	C	-0.0806	0.0039
36	81YL3h23:8	4	C	0.0478	-0.0052
37	84YL4M60:4	4	W	0.0415	-0.0958

*Context P: Palace area; W: Workshop area; C: Commoner area(area rather than palace and workshop area)

*Phase 4: Phase 4 early stage; 4 late: Phase 4 late stage.

Table 13 PC scores of Storage Zun from Erlitou site in GMM analysis

#	Sample	Phase	Context	PC1	PC2
1	2·5T116(6):11	1	P	-0.1383	-0.0365
2	2H216:18	1	C	-0.0689	-0.0197
3	8H53:13	1	C	-0.1689	-0.0315
4	3H233:3	2	C	-0.0750	0.0252
5	4M6:1	2	M	-0.1127	-0.0463
6	3H232:15	2	C	-0.0677	0.0581
7	2C:2	2	C	-0.1034	-0.0328
8	3·5H249:7	2	P	-0.1127	0.0122
9	2·5H132:30	2	P	-0.0778	0.0132
10	3·5H249:8	2	P	-0.1029	-0.0003
11	2004-5M19:4	2	M	-0.0752	0.0249
12	2002-5H85:5	2	P	-0.0441	0.0422
13	2003-M7:1	2	M	-0.0797	-0.0570
14	5M23:2	2	M	-0.1341	-0.0230
15	2001-5H12:9	2	P	-0.1449	-0.0518
16	2001-5H8:1	2	P	-0.1202	-0.0501
17	4M14:1	2	M	-0.0889	0.0001
18	9M15:2	2	M	-0.0473	0.0389
19	3T5(6):2	2	C	-0.0046	0.0462
20	9H30:3	2	C	0.0454	0.0104
21	9H30:4	2	C	-0.0324	0.0177
22	4T24(4)D:12	3	W	0.0313	0.0649
23	2T203 灰沟 : 11	3	C	0.0583	-0.0194
24	8C : 8	3	C	0.0726	-0.0315
25	8T14(4):11	3	C	0.0558	-0.0100
26	4H76:78	3	W	0.0474	-0.0139
27	4T8(3):18	3	W	-0.0189	-0.0069
28	3H228:12	3	C	-0.0659	0.0207
29	4T8(3):14	3	W	-0.0745	0.0103
30	6H6 : 8	3	C	0.0496	-0.0194
31	2002-5H143 : 9	3	P	-0.0296	0.0463
32	4M17:4	3	M	-0.0476	0.0485
33	2002-5H92:8	3	P	0.0648	0.0101
34	6M20:4	3	M	-0.1038	0.0199
35	2006-5VT20 剖 (4) F : 3	3	P	-0.0278	0.0014
36	6H6 : 7	3	C	0.0681	-0.0314
37	4H10:2	3	W	0.0623	0.0131
38	5H1:11	4 late	P	0.0138	0.0419
39	2·5H133:11	4	P	0.0686	0.0052
40	5H83:24	4 late	P	0.0687	0.0176
41	5H101:25	4 late	P	0.0506	0.0220

42	5H101:17	4 late	P	0.1011	-0.0004
43	6M9 东 H:1	4	M	0.0645	-0.0261
44	5T214(3)B:13	4	P	0.0238	-0.0271
45	6M28:8	3	M	0.0004	0.0386
46	2002-5H92:44	4 late	M	-0.0230	0.0494
47	6M11:3	4	M	0.0717	0.0003
48	6M1:3	4	M	0.0386	0.0211
49	2000-3H24:65	4 late	C	0.0733	0.0019
50	2000-3H24:111	4 late	C	0.0856	-0.0237
51	2002-5T22(4)B:1	4 late	P	0.0523	-0.0361
52	2000-3T3(5)B:24	4 late	C	0.1024	-0.0479
53	2000-3T3(5)B:32	4 late	C	0.0674	0.0079
54	2002-5H150:19	4 late	P	0.0724	0.0332
55	2001-5H272:19	4 late	P	0.1183	-0.0020
56	2002-5H112:17	4 late	P	0.0490	0.0276
57	3H10:8	4 late	C	0.1144	-0.0143
58	3H23:9	4 late	C	0.0211	-0.0059
59	2003-5G14:49	4 late	P	0.0847	-0.0245
60	2003-M11:4	4 late	M	0.0678	-0.0303
61	6M9:14	4	M	0.0708	-0.0148
62	6M9:13	4	M	0.0835	-0.0323
63	2000-3H13 (3) : 15	3	C	0.0704	-0.0240

*Context P: Palace area; W: Workshop area; C: Commoner area(areas rather than palace and workshop area); M: burials.

*The phase 4 in storage, serving and drinking vessels refers to the entire phase 4th.

Table 14 PC scores of serving Dou from Erlitou site in GMM analysis

#	Samples	Period	Context	PC1	PC2
1	84YL4M51:7	2	M	1.0389	-0.0893
2	82YL5T15(10):1	1	P	0.8709	-0.1773
3	85YL4M7:6	2	M	0.0568	0.2036
4	87YL6M49:5	2	M	0.1269	0.2423
5	84YL 4M72:6	2	M	0.6441	0.5095
6	84YL 4M72:7	2	M	-1.0107	-0.0504
7	91YL6H109:2	2	C	-0.2701	0.8950
8	82YL5H29:2	2	P	-0.6351	0.0137
9	87YL6M23:3	3	M	1.1447	-0.1726
10	87YL9T2(4):1	2	C	0.6652	-0.7252
11	87YL6M41:5	3	M	0.2507	-0.1416
12	87YL6M41:3	3	M	0.5159	0.5766
13	94YL 12M2:6	2	M	0.6161	0.1537
14	87YL5M25:3	3	M	-0.8160	0.2772
15	94YL 12M2:2	2	M	-0.8586	-0.2452
16	82YL8H8:1	2	C	0.8032	0.4063
17	94YL 12M2:1	2	M	-1.3781	0.1017
18	82YL8H22:1	3	C	1.3555	-0.5624
19	82YL9M8:6	3	M	0.7967	-0.7840
20	84YL6M3:3	4	M	0.2264	0.0046
21	87YL6M20:5	3	M	1.3649	0.6945
22	87YL6M20:6	3	M	-1.2324	-0.0834
23	82YL9M8:7	3	M	0.1805	0.1807
24	84YL6M3:4	4	M	-2.6499	-0.1912
25	82XL9M9:3	3	M	-2.5973	-0.2105
26	86YL4H23:4	4 late	W	0.8303	-0.8225
27	86YL4H23:3	4 late	W	0.3546	0.1723
28	81YL4T1 (2) : 2	4	W	-0.5737	-0.0768
29	85YL5H27:7	4	P	-2.0364	0.0337
30	82YL4M13:6	4	M	0.0917	-0.0456
31	86YL4H23:2	4	W	-0.4821	0.2465
32	5M15:10	2	M	0.9965	0.3384
33	4M8:8	2	M	2.2763	0.4317
34	5M15:6	2	M	1.0773	0.2230
35	5M23:7	2	M	1.1394	0.3590
36	4M6:8	2	M	1.4752	0.3976
37	4H63:32	2	W	0.5072	0.2277
38	4M18:1	2	M	-0.0305	0.2762
39	2·5H148:20	1	P	-1.0459	0.0017
40	4M6:7	2	M	-0.8230	0.0070
41	5M15:18	2	M	1.8433	-0.4892

42	5M15:1	2	M	1.5967	-0.5910
43	5M23:6	2	M	2.1892	-0.7322
44	2001-5H44:8	2	P	-2.3324	-0.3096
45	2002-5G10(1):8	2	P	0.0529	0.0958
46	4M8:7	2	M	1.4878	-0.4240
47	4M14:2	2	M	1.2140	-0.6828
48	4M14:4	2	M	0.6161	0.1696
49	6M8:3	2	M	0.8649	0.2238
50	4M15:5	2	M	0.0843	-0.0246
51	2002-5M3:26	2	M	1.0258	0.0029
52	2002-5H92:11	2	P	0.7795	0.0120
53	2002-5M3:6	2	M	1.9237	0.2954
54	2002-5M3:29	2	M	1.4215	-0.0174
55	2002-5M4:3	2	M	1.8137	0.2601
56	2002-5M4:10	2	M	4.6467	-0.8764
57	2002-5H84:3	2	P	-1.2636	0.0106
58	2004-5M19:5	2	M	1.1084	0.4156
59	9M20:7	2	M	-0.4422	0.0970
60	3M5:1	2	M	0.4139	0.4048
61	6M5:2	2	M	-2.3900	-0.2300
62	81YLV5:3	2	M	0.7104	-0.4118
63	3M3:2	2	M	-2.6135	-0.2071
64	81YLV5:2	2	M	-0.1520	0.3399
65	6M49:5	2	M	-0.3774	0.2949
66	6M41:5	3	M	0.1951	-0.2244
67	6M41:3	3	M	0.2489	0.5396
68	9M8:7	3	M	0.4145	-0.3608
69	6M25:3	3	M	-1.0372	0.0823
70	6M20:5	3	M	0.1122	0.2144
71	6T4(3):11	3	C	0.1111	0.3470
72	2H225:11	3	C	-1.3693	0.0604
73	8T22(3):11	3	C	-2.4363	-0.1064
74	4H34:12	3	C	-2.1106	-0.1208
75	9M9:3	3	M	-2.6469	-0.2121
76	6M20:5	3	M	1.6824	0.4071
77	6M23:3	3	M	1.2158	-0.3414
78	6M20:6	3	M	-0.9634	-0.1793
79	6M3:3	4	M	0.6353	0.4325
80	5M21 : 5	4 late	M	0.0549	-0.3294
81	5M21 : 2	4 late	M	1.0218	0.0849
82	6M1:2	4	M	-1.0725	-0.0168
83	2004-5M17:2	4 late	M	-1.5267	0.0961
84	5H101:14	4 late	P	-1.5791	0.1131

85	81YLVM5:2	2	M	-2.7646	-0.2268
86	2003-5M11:3	4 late	M	-2.7345	-0.2738

*Context P: Palace area; W: Workshop area; C: Commoner area(areas rather than palace and workshop area); M: burials.

*The phase 4 in storage, serving and drinking vessels refers to the entire phase 4th.

Table 15 PC scores of Jue from Erlitou culture in GMM analysis

#	Sample	Period	Location	White or not	PC1	PC2
1	4M11:1	2	Erlitou	No	1.6911	0.2844
2	2001-5M1:10	2	Erlitou	Yes	0.6344	-0.0608
3	4M14:5	2	Erlitou	No	0.8963	-0.5520
4	4M11:5	2	Erlitou	No	2.3943	0.6426
5	5M15:3	2	Erlitou	No	1.9238	1.0294
6	2001-5M1:8	2	Erlitou	No	0.2768	-0.5674
7	6M8:2	2	Erlitou	No	0.7190	0.2542
8	9M20:10	2	Erlitou	No	0.1018	-0.7740
9	6M7:5	2	Erlitou	No	-0.3766	0.1010
10	2002-5M3:24	2	Erlitou	No	0.9361	0.1043
11	6M43:3	2	Erlitou	No	0.5478	-0.0985
12	3M5:2	2	Erlitou	No	0.6131	-0.4517
13	2002-5M4:7	2	Erlitou	No	-0.3531	-0.4741
14	9M15:5	2	Erlitou	No	0.1657	0.3881
15	6M44:5	3	Erlitou	No	-0.7415	0.0045
16	3M3:7	3	Erlitou	No	0.1166	0.5919
17	9M8:4	3	Erlitou	No	-0.4337	0.2599
18	81YLV3:9	3	Erlitou	No	-0.4523	0.2864
19	6M28:9	3	Erlitou	No	-0.1680	0.1395
20	6KM6 上 : 3	4	Erlitou	No	0.2832	0.1872
21	6T3(2)下 : 13	4	Erlitou	No	-1.3716	-0.0372
22	87YL6M49:3	2	Erlitou	No	0.6052	-0.2105
23	84YL4M72:2	2	Erlitou	No	0.3136	-0.1998
24	84YL4T53(4C):1	2	Erlitou	Yes	-0.0408	-0.4889
25	6M11:20	4	Erlitou	No	-0.7604	0.4129
26	82YL9M14:4	3	Erlitou	No	0.2062	0.5015
27	82YL9M8:4	3	Erlitou	No	-0.5530	0.3102
28	90YL9M1:2	3	Erlitou	No	-1.0010	0.3973
29	87YL4M44:5	3	Erlitou	No	-1.1548	0.1066
30	82YL4M13:4	4	Erlitou	No	-1.0968	0.5569
31	85YL6M13:3	4	Erlitou	No	-0.2098	0.3950
32	T91M28:1	4	Nanzhai	Yes	-0.0551	0.0609
33	T85M26:3	2	Nanzhai	No	0.6634	-0.4913
34	H48:4	3	Zhengyao	No	0.3142	-0.9483
35	M2:3	2	Dongmagou	No	-0.1916	0.4866
36	82M3:6	1	Nanzhai	Yes	-0.2977	-1.2349
37	H308:11	3	Luodamiao	No	-0.7089	0.3225
38	YPNT85M26:3	2	Nanzhai	No	0.6862	-0.6694
39	M5:4	1	Gongxian	No	0.2702	-0.4378
40	YPNT90M10:5	4	Nanzhai	Yes	-0.0366	0.2153
41	M2:1	2	Rangdong	No	-0.6839	0.1863

42	YPNT82M3:4	1	Nanzhai	Yes	-0.1808	-1.1931
43	2T6502M1:7	3	Nanwa	Yes	-0.2657	0.4221
44	none	2	Yucun	Yes	-0.0158	-0.6899
45	T22 (2) B:1	2	Yangzhuang	Yes	0.2881	0.4002
46	T21(6):17	2	Yangzhuang	No	0.3260	-0.0610
47	T4(2):5	3	Baliqiao	No	-1.2953	0.1714
48	M401:2	2	Dongxiafeng	No	-1.3399	0.0395
49	H6:1	2	Yangzhuang	No	-0.4953	0.2975
50	T21(7):5	2	Yangzhuang	No	-0.4986	-0.0389
51	T21(4):11	2	Yangzhuang	No	-0.1941	0.1233

Table 16 PC scores of He from Erlitou culture in GMM analysis

#	Sample	Period	Location	White or not	PC1	PC2
1	6M8:1	2	Erlitou	No	0.3513	0.0334
2	5M23:1	2	Erlitou	No	-0.1730	-0.0758
3	4M8:9	2	Erlitou	No	-0.2464	0.0159
4	2006-5VT117 剖 (5) C : 19	2	Erlitou	No	-0.0716	0.3238
5	4M14:6	2	Erlitou	No	0.3578	-0.0822
6	4M11:2	2	Erlitou	No	-0.5509	0.0597
7	2001-5M1:7	2	Erlitou	Yes	4.4833	-0.2069
8	2002-5M3:30	2	Erlitou	No	0.2161	-0.1395
9	2001-5M1:17	2	Erlitou	Yes	0.6089	0.0614
10	9M15:4	3	Erlitou	No	-0.0198	0.0623
11	9M20:9	3	Erlitou	No	-0.1864	0.1586
12	2002-5M4:6	2	Erlitou	No	-0.1708	0.0859
13	9M8:5	3	Erlitou	No	-0.3361	0.0435
14	3M2:7	3	Erlitou	No	-0.1811	-0.0668
15	4M17:3	2	Erlitou	No	0.6261	-0.0124
16	6M7:1	3	Erlitou	No	0.2349	-0.1874
17	3KM2:4	3	Erlitou	No	-0.1953	-0.0302
18	6KM3:10	3	Erlitou	No	-0.1603	-0.1193
19	85YL6M14:1	3	Erlitou	No	0.2944	-0.2107
20	3M2:7	3	Erlitou	No	-0.3610	-0.1571
21	6M44:6	3	Erlitou	No	0.0512	-0.0832
22	6M28:5	3	Erlitou	No	-0.0274	-0.0123
23	4M12:1	4	Erlitou	No	-0.1766	0.0283
24	6M6:1	4	Erlitou	No	-0.2013	-0.1111
25	6T3(2)下 : 12	4	Erlitou	No	-0.1796	-0.2513
26	6M6:1	4	Erlitou	No	-0.5386	-0.0039
27	6M57:19	4	Erlitou	No	-0.2868	-0.1815
28	6M6:4	4	Erlitou	Yes	-0.2038	-0.0025
29	6M9:5	4	Erlitou	Yes	0.1721	-0.0958
30	6M11:21	4	Erlitou	Yes	-0.1830	0.0512
31	6M11:22	4	Erlitou	Yes	-0.1860	0.0633
32	85YL6M7:3	2	Erlitou	No	-0.0044	0.1242
33	82XL9M20:9	2	Erlitou	No	-0.0828	0.0498
34	87YL4M44:6	3	Erlitou	No	-0.0735	-0.0541
35	84YL4T15(2B):1	2	Erlitou	Yes	0.2807	0.1926
36	82YL9M8:5	3	Erlitou	No	-0.1480	0.0847
37	82YL9M14:3	3	Erlitou	No	-0.1182	0.0550
38	82YL9M15:4	2	Erlitou	No	-0.0577	0.0765
39	83YL4M45:2	2	Erlitou	No	-0.4767	0.1512

40	84YL4M51:2	2	Erlitou	No	-0.3375	0.1280
41	84YL6M11:22	4	Erlitou	No	-0.1088	-0.0523
42	82YL4M13:5	4	Erlitou	No	-0.2378	-0.1064
43	84YL6M11:21	4	Erlitou	No	-0.3009	-0.0572
44	87YL6M57;19	4	Erlitou	No	-0.2511	-0.1951
45	85YL5H27:8	4	Erlitou	No	-0.2137	0.0225
46	85YL6M13:2	4	Erlitou	No	-0.4224	-0.0503
47	80YL3M2:7	3	Erlitou	No	-0.3060	-0.0219
48	YPNT93H81:1	2	Nanzhai	Yes	1.3168	0.4823
49	T82M3:6	1	Nanzhai	Yes	0.6808	0.2233
50	YPNT82M3:6	1	Nanzhai	Yes	0.3713	0.3904
51	M5:1	2	Dongmagou	Yes	0.5003	-0.1071
52	YPNT91M28:2	4	Nanzhai	Yes	-0.3655	0.0345
53	T91M28:2	4	Nanzhai	Yes	-0.4117	0.0316
54	T19(2):11	2	Yangzhuang	No	-0.4546	0.0653
55	YPNT90M10:6	4	Nanzhai	Yes	-0.3221	-0.0995
56	T22(2)B:20	2	Yangzhuang	No	-0.7008	0.0162
57	M1:2	3	Xishicun	No	-0.4077	-0.2574
58	H5:25	2	Tuoli	No	-0.0751	-0.0728

*No.7 is the outlier

#4 The dimension information of pottery

Table 17 The rim size of Cooking Jia from Taosi site

#	Sample	Context	Period	Rim	#	Sample	Context	Period	Rim
1	H325:7	C	Early	12	26	M2172:31	M2	Early	16.6
2	IH102:29	C	Early	8.9	27	M2180:21	M2	Early	17.5
3	IIT1(3)B:10	C	Early	17.4	28	M2027:1	M2	Early	18.2
4	T310(4):14	C	Early	19.3	29	M2079:9	M2	Early	11.2
5	H439:3	C	Early	17.5	30	M2103:9	M2	Early	11.8
6	H442:2	C	Early	18	31	M2035:6	M2	Early	12.2
7	H333:25	C	Early	14	32	M1111:4	M2	Early	12.3
8	M3015:26	M1	Early	27	33	M2035:4	M2	Early	15.4
9	M2001:58	M1	Early	29.8	34	M2180:8	M2	Early	15
10	M3016:13	M1	Early	23.4	35	M2115:9	M2	Early	33.5
11	M3015:30	M1	Early	18.3	36	M2112:7	M2	Early	28.9
12	M3002:32	M1	Early	24.3	37	M2043:9	M2	Early	30.2
13	M2001:59	M1	Early	27.2	38	M2035:10	M2	Early	29
14	M3072:13	M1	Early	18.6	39	M2168:6	M2	Early	30.2
15	M2001:6	M1	Early	17	40	M2172:17	M2	Early	36.5
16	M3016:10	M1	Early	19	41	M2014:10	M2	Early	27
17	M3002:25	M1	Early	19	42	M2079:10	M2	Early	34.6
18	M2053:5	M2	Early	21.4	43	M1111:6	M2	Early	27.8
19	M2202:3	M2	Early	18	44	M2103:16	M2	Early	29.9
20	M2063:3	M2	Early	21.3	45	M2027:8	M2	Early	29.2
21	M2115:6	M2	Early	16.4	46	M2092:23	M2	Early	30.3
22	M2043:4	M2	Early	17.7	47	M2180:15	M2	Early	31
23	M2103:27	M2	Early	17.7	48	M2014:7	M2	Early	27
24	M2039:3	M2	Early	17.6	49	M2005:1	M2	Early	17.9
25	M2168:21	M2	Early	17.5	50	M2092:2	M2	Early	16.4

Table 18 The rim size of Storage jars with large orifice from Taosi site

#	Sample	Context	Period	Rim	#	Sample	Context	Period	Rim
1	H393:1	C	Early	33.3	22	M3015:58	M1	Early	28.4
2	H393:12	C	Early	34	23	M3015:59	M1	Early	29.5
3	IIH4:21	C	Early	40	24	M3015:27	M1	Early	29.2
4	T311(4)A:21	C	Early	26.6	25	M2095 : 6	M2	Early	26.8
5	J40:35	C	Early	24	26	M2035:17	M2	Early	29.4
6	IIIC:03	C	Early	31.5	27	M2103:29	M2	Early	16.9
7	T431 (4) E:31	C	Early	23.6	28	M2168:25	M2	Early	17.9
8	IIH4:41	C	Early	24.8	29	M2168:23	M2	Early	17.2
9	IIT1(3)C:66	C	Early	26	30	M2035:16	M2	Early	30
10	IIH4:24	C	Early	33	31	M2180:16	M2	Early	25.4
11	H332:11	C	Early	23.2	32	M2169:13	M2	Early	30
12	M3073:20	M1	Early	28.5	33	M2014:1	M2	Early	31.5
13	M2001:44	M1	Early	28.5	34	M2014:2	M2	Early	32
14	M2001:45	M1	Early	27.8	35	M2092:9	M2	Early	27
15	M2001:69	M1	Early	29	36	M2043:11	M2	Early	21
16	M3016:6	M1	Early	22.2	37	M2112:5	M2	Early	26
17	M3016:7	M1	Early	22	38	M2168:16	M2	Early	30
18	M3015:38	M1	Early	27.4	39	M2095:5	M2	Early	30.6
19	M3002:8	M1	Early	25.3	40	M2172:18	M2	Early	37.2
20	M3002:54	M1	Early	24	41	M2103:14	M2	Early	33.8
21	M3002:9	M1	Early	23.5					

Table19 The rim size of Serving Dou from Taosi site

#	Sample	Context	Period	Rim	#	Sample	Context	Period	Rim
1	J301:23	C	early	22	35	M2095:2	M2	early	15
2	J402:43	C	early	20	36	M2095:3	M2	early	16.1
3	H374:9	C	early	43	37	M2043:2	M2	early	18.1
4	H374:8	C	early	43	38	M2172:14	M2	early	17
5	99-2H6:14	C	early	31.6	39	M2043:8	M2	early	38.4
6	IIH102:66	C	early	18.5	40	M2168:30	M2	early	17.2
7	T310(3)B:15	C	early	37.4	41	M2168:31	M2	early	16.4
8	IIH103:9	C	early	28	42	M2168:36	M2	early	16.5
9	M2001:37	M1	early	21.3	43	M2035:19	M2	early	12.7
10	M2001:38	M1	early	21.6	44	M2092:13	M2	early	13
11	M2001:35	M1	early	18.1	45	M2035:18	M2	early	13.8
12	M2001:40	M1	early	17.6	46	M2103:18	M2	early	15.5
13	M2001:28	M1	early	18	47	M2079:1	M2	early	17
14	M2001:31	M1	early	18.3	48	M2079:2	M2	early	16
15	M2001:32	M1	early	18.1	49	M2079:3	M2	early	16
16	M2001:33	M1	early	18	50	M2092:12	M2	early	14.2
17	M2001:34	M1	early	18.7	51	M2092:14	M2	early	14.3
18	M2001:36	M1	early	18.8	52	M2092:15	M2	early	14.5
19	M2001:39	M1	early	18.6	53	M2092:16	M2	early	14.9
20	M3072:5	M1	early	19	54	M2172:11	M2	early	15
21	M3072:18	M1	early	18	55	IIITG4 : 5	C	middle	20
22	M3073:12	M1	early	18.2	56	IIH3 : 28	C	middle	23.6
23	M3073:13	M1	early	19.1	57	2HG3(2):18	C	middle	18.8
24	M3073:14	M1	early	19.2	58	2TG5(3):2	C	middle	18
25	M3073:15	M1	early	18.2	59	2HG3(1):2	C	middle	20
26	M3073:16	M1	early	18.2	60	HG8:80	C	late	16
27	M2001:29	M1	early	19.2	61	H303:19	C	late	28.8
28	M2001:30	M1	early	19.6	62	H376:24	C	late	14.7
29	M2001:71	M1	early	20.6	63	H352:21	C	late	16
30	M2115:5	M2	early	14.6	64	H3403:12	C	late	20.4
31	M2168:37	M2	early	15.5	65	H318:26	C	late	12.4
32	M2172:12	M2	early	15.8	66	H301:5	C	late	18.44
33	M2172:13	M2	early	14.5	67	F320:1	C	late	25.6
34	M2180:7	M2	early	17.5	68	H6:37	C	late	28.2

Table 20 The rim size of Cooking Li from Taosi site

#	Sample	Period	Rim	#	Sample	Period	Rim
1	IIIC:02	middle	35.7	29	H303:12	late	32.4
2	H416:22	middle	31.3	30	99 2H22 : 12	late	13.4
3	H416:23	middle	29.2	31	02H6 : 36	late	18.5
4	T403(5):57	middle	26	32	H301:6	late	42.7
5	H430:6	middle	24.5	33	H3403:6	late	31.2
6	T355(3)1B : 32	middle	12	34	T399(3)A:6	late	33.8
7	IIITG4 (3) : 2	middle	26.8	35	IIIH2 : 2	late	28
8	IIITG4 (3) : 4	middle	24.8	36	T421 (4) D : 23	late	16.5
9	2TG10(5):11	middle	15	37	T404 (4) :11	late	17
10	2HG3(1):10	middle	30	38	H376 : 28	late	17
11	99 2H10 : 5	middle	29	39	H425 : 40	late	14.5
12	H1:1	middle	23	40	2HG3(2):19	late	14
13	H3421:6	middle	27.5	41	99 2H22 : 4	late	8.98
14	IIIH7 : 1	middle	33.6	42	02T5126(3):3	late	15.4
15	H365 : 38	middle	14.3	43	J401 : 111	late	15.4
16	T406 (4) F : 11	middle	12.6	44	99 2H22 : 1	late	19
17	H321 : 1	middle	9.8	45	H302 : 29	late	18.5
18	H365 : 7	middle	8.5	46	H423 : 41	late	18
19	H321 : 4	middle	13.9	47	H302 : 24	late	10.5
20	H421 : 17	middle	14	48	H376:29	late	15.5
21	H408 : 2	middle	11.2	49	T403(4)C:49	late	16.7
22	T404 (5) : 69	middle	11	50	H401:22	late	16
23	H430 : 5	middle	15.8	51	J401:112	late	10.5
24	H301:8	late	21.5	52	J401:139	late	13
25	IIIH2 : 3	late	13.6	53	IIIH3 : 22	late	13.6
26	2TG10HG3(4):35	late	21.5	54	H3403:11	late	20
27	99 2T7 (4) A : 4	late	22	55	T355(3)1A : 32	late	22.9
28	99 2H13 : 4	late	31	56	H302 : 26	late	15.5

Table 21 The rim size of Cooking Jars from Erlitou site

#	Sample	Phase	Context	Rim	#	Sample	Phase	Context	Rim
1	2H216:11	1	C	28	185	2002-5G38(2):10	2	P	20
2	2H216:13	1	C	22.5	186	2002-5G38(1):24	2	P	25
3	2-5H103:11	1	P	23	187	2002-5G38(1):32	2	P	23
4	2-5T104(5):31	1	P	21	188	2002-5G38(1):33	2	P	24
5	7H53:12	1	C	17.4	189	2002-5G38(1):55	2	P	23
6	7T15(6):11	1	C	22.8	190	2001-5H24:6	2	P	17
7	2-5H106:13	1	P	26	191	2002-5H57:4	2	P	21.6
8	2-5T104(7):19	1	P	22	192	2002-5H57:11	2	P	25
9	5H74:9	1	P	17	193	2002-5H57:8	2	P	25
10	2-5H118:12	2	P	24.2	194	2002-5H102:6	2	P	18
11	5H110:10	2	P	20.9	195	2002-5H104:11	2	P	19
12	4T7(5)B:11	2	W	24	196	2003-5H211:2	2	P	21
13	4T3(7):11	2	W	22.9	197	2003-5H211:29	2	P	25
14	4T9(6):11	2	W	18.6	198	2003-5H211:30	2	P	19
15	4H63:42	2	W	22	199	2003-5H211:37	2	P	30
16	4H88:16	2	W	25	200	2003-5H211:16	2	P	25.8
17	5M202 填土 : 1	2	P	12.5	201	2003-5H211:28	2	P	22
18	4H43:16	3	W	22.5	203	2003-5H211:47	2	P	22
19	4T24(4)D:14	3	W	21.9	204	2003-5H211:4	2	P	13.8
20	4T24(4)D:11	3	W	21.58	205	2002-5H462:1	2	P	24
21	4T5(4):11	3	W	18.5	207	2001-5G2:3	2	P	22
22	4H76:96	3	W	19	208	2002-5G7:3	2	P	25
23	4T11(4):42	3	W	21.8	209	2003-5G13:18	2	P	20
24	4T11(4):60	3	W	22	210	2003-5G13:19	2	P	16.5
25	4T10(2):12	3	W	21	211	2003-5G13:17	2	P	18
26	4H57:14	3	W	19.5	212	2001-5H28:22	2	P	22
27	3-5H240:61	3	P	19	213	2001-5H28:19	2	P	21
28	3H240:93	3	C	22	214	2001-5H28:21	2	P	23
29	2H226:18	3	C	24	215	2001-5H28:20	2	P	24
30	3-5H240:94	3	P	19	216	2001-5H44:15	2	P	19
31	5H201:13	3	P	22.2	217	2001-5H44:20	2	P	24
32	3-5H240:95	3	P	22	218	2001-5H44:11	2	P	22.7
33	4T11(4):19	3	W	13.8	219	2001-5H45:12	2	P	22.5
34	2h226:31	3	C	14	220	2002-5H72:5	2	P	22
35	5T201(3):23	4	P	21	221	2002-5H84:6	2	P	24
36	5T201(3):11	4	P	18	222	2002-5H85:4	2	P	17
37	5H87:15	4 late	P	20	223	2002-5H109:1	2	P	21
38	5T12B(3)B:12	4	P	19.9	224	2002-5H117:9	2	P	22
39	5T2EH:11	4	P	19.1	225	2002-5H117:5	2	P	23
40	6M9 上:1	4	C	27.8	226	2002-5H117:10	2	P	23

41	2-5H133:13	4	P	18	227	2002-5H125:2	2	P	24
42	5H53:23	4 late	P	20.2	228	2002-5H129:5	2	P	23
43	5H53:11	4 late	P	17.3	229	2003-5H217:3	2	P	18
44	5H83:26	4 late	P	19.7	230	2002-5T13G1:15	2	P	23
45	5H53:12	4 late	P	19.8	231	2002-5H92:6	3	P	22
46	2000-3T4(17):13	3	C	22	232	2002-5H92:7	3	P	22.5
47	2000-3T4(15):8	3	C	19	233	2001-5H13:3	3	P	22
48	2000-3T4(16):3	3	C	22	234	2001-5H19:5	3	P	22
49	2000-3T4(16):4	3	C	23	235	2001-5H22:5	3	P	22
50	2000-3T4(17):10	3	C	22	236	2001-5H27:5	3	P	21
51	2000-3T4(17):9	3	C	25	237	2001-5H27:6	3	P	25
52	2000-3T4(11):13	4 late	C	22	238	2001-5H37:6	3	P	20
53	2000-3T4(11):14	4 late	C	23	239	2001-5H37:7	3	P	22
54	2000-3T4(13):11	4	C	20	240	2001-5H38:5	3	P	23
55	2000-3T4(13):7	4	C	21	241	2001-5H38:4	3	P	22
56	2000-3T4(11):11	4 late	C	21.5	242	2001-5H38:8	3	P	22
57	2000-3T1(6):20	4	C	18	243	2002-5H60:1	3	P	28
58	2000-3T1(7):25	4 late	C	19	244	2002-5H143 : 1	3	P	21
59	2000-3T1(8):18	4 late	C	20	245	2006-5H166:4	3	P	23
60	2000-3T1(8):27	4 late	C	17	246	2006-5H166:6	3	P	24
61	2000-3T1(9):3	4 late	C	19	247	2006-5H166:5	3	P	21
62	2000-3T1(9):4	4 late	C	20	248	2006-5H446:1	3	P	21.5
63	2000-3T1(9):6	4 late	C	17	249	2006-5H446:3	3	P	22
64	2000-3T1(9):9	4 late	C	19	250	2006-5H453:1	4 late	P	23
65	2000-3T3(5)B:10	4 late	C	19	251	2002-5H111:19	4 late	P	22
66	2000-3T3(5)B:18	4 late	C	21	252	2002-5H112:16	4 late	P	20.5
67	2000-3T1(7):29	4 late	C	22	253	2002-5H139:7	4 late	P	18
68	2000-3T1(8):20	4 late	C	20	254	2002-5H139:6	4 late	P	21
69	2000-3T1(9):11	4 late	C	21.7	255	2002-5H147:21	4 late	P	20.6
70	2000-3T2(5)A:11	4 late	C	23	256	2002-5H147:11	4 late	P	24
71	2000-3T2(5)A:25	4 late	C	20	257	2003-5H174:2	4 late	P	17
72	2000-3T2(5)B:13	4 late	C	22	258	2003-5H228 : 17	4 late	P	21

73	2000-3T2(5)B:33	4 late	C	20	259	2003-5H228 : 18	4 late	P	19
75	2000-3T2(5)A:15	4 late	C	21	260	2003-5H228 : 19	4 late	P	19
76	2000-3T2(5)A:6	4	C	22	261	2003-5H232 : 4	4 late	P	21
77	2000-3H1:27	2	C	25	263	2003-5H247 : 5	4 late	P	16
78	2000-3H26:2	2	C	22	264	2003-5H247 : 4	2	P	23
79	2000-3H26:4	2	C	24	265	2001-5H272:7	4 late	P	19.8
80	2000-3H26:5	2	C	25	266	2001-5H272:8	4 late	P	19.4
81	2000-3H28:9	3	C	21	267	2001-5H272:18	4 late	P	19
82	2000-3H28:10	3	C	21.5	268	2004-5H285:14	4 late	P	21
83	2000-3H19 : 3	3	C	18	269	2004-5H285:12	4 late	P	21
84	2000-3H20 : 10	3	C	20	270	2006-5H447:10	4 late	P	19
85	2000-3H20 : 12	3	C	23	271	2006-5H447:11	4 late	P	21
86	2000-3H20 : 15	3	C	21	272	2006-5H447:29	4 late	P	18
87	2000-3H20 : 21	3	C	23	273	2006-5H448:2	4 late	P	21
88	2000-3H20 : 18	2	C	20	274	2006-5H450:12	4 late	P	22
89	2000-3H20 : 19	2	C	21	275	2001-5H465:10	4	P	21
90	2000-3H13 (2) : 1	4	C	21	276	2001-5H465:6	4	P	20
91	2000-3H13 (3) : 6	4	C	21	277	2003-5G14:72	4 late	P	19
92	2000-3H13 (3) : 11	4	C	23	278	2003-5G14:73	4 late	P	18
93	2000-3H13 (3) : 8	4	C	22	279	2003-5G14:81	4 late	P	20
94	2000-3H13 (2) : 4	4	C	20	280	2003-5G14:83	4 late	P	22
95	2000-3H13 (1) : 31	4 late	C	19	281	2003-5G14:106	4 late	P	19
96	2000-3H13 (1) : 32	4 late	C	16	282	2003-5G14:94	4 late	P	17.5
97	2000-3H13 (3) : 9	4	C	19	283	2003-5G14:104	4 late	P	22
98	2000-3H13 (2) : 2	4	C	21	284	2003-5G14:132	4 late	P	15
99	2000-3H13 (1) : 14	4 late	C	24	285	2003-5G14:133	4 late	P	19.5
100	2000-3H8:7	4 late	C	20	286	2003-5G14:134	4 late	P	21
101	2000-3H8:10	4 late	C	20	287	2003-5G14:135	4 late	P	19.5
102	2000-3H8:13	4 late	C	27	288	2003-5G14:136	4 late	P	7
103	2000-3H8:17	4 late	C	18	289	2003-5G14:137	4 late	P	7
104	2000-3H8:19	4 late	C	17	290	2003-5G14:138	4 late	P	7

106	2000-3H18:11	4 late	C	22	291	2002-5M3:4	2	P	19
107	2000-3H18:6	2	C	20	292	2001-5T4D2HC:15	3	P	23
108	2000-3H22:5	4 late	C	19	293	2001-5T4D2HC:24	3	P	21
109	2000-3H22:6	4 late	C	24	294	2001-5T4D2HC:40	3	P	23
110	2000-3H24:33	4 late	C	21	295	2001-5T4D2HC:1	3	P	23
111	2000-3H24:54	4 late	C	21	296	2001-5T4D2HC:11	3	P	25
112	2000-3H24:45	4 late	C	27	297	2001-5T4D2HC:12	3	P	21
113	2000-3H24:52	4 late	C	21	298	2001-5T4D2HC:23	3	P	22
114	2000-3H24:53	4 late	C	21	299	2001-5T4D2HC:7	3	P	22
115	2000-3H24:55	4 late	C	22	300	2001-5T4D2HC:39	3	P	21
116	2005-5VT104 剖 (5) E : 1	2	P	21	301	2001-5H43:2	2	P	21
117	2006-5VT117 剖 (5) E : 2	2	P	28	302	2002-5H156:1	2	P	23
118	2003-5VT62 剖 (5) C : 1	2	P	14	303	2002-5H156:8	2	P	22
119	2003-5VT32 剖 (5) B : 1	2	P	19	304	2002-5H157:5	2	P	23
120	2006-5VT117 剖 (5) C : 2	2	P	21	305	2002-5H173:1	2	P	23
121	2002- 5T12(5)B:3	2	P	22	306	2002-5H173:2	2	P	23
122	2002-5T17(5):3	2	P	20	307	2003-5H215:1	2	P	23
123	2003-5VT33 剖 (5) B : 2	2	P	18	308	2003-5H215:3	2	P	20
124	2003-5VT62 剖 (5) A : 1	2	P	19	309	2004-5H279 : 3	2	P	22
125	2003-5VT78 剖 (5) A : 2	2	P	24	310	2004-5H280:2	2	P	20
126	2006-5VT117 剖 (5) A : 1	2	P	26	311	2005-5H409:6	2	P	20
127	2002- 5T6(5)B:10	2	P	24	312	2005-5H416:6	2	P	22
128	2002- 5T12(5)B:2	2	P	24	313	2005-5H421:4	2	P	20
129	2006-5VT117 剖 (5) A : 4	2	P	25	314	2002-5H467:1	2	P	16
130	2002-5T4(5)A:1	2	P	23	315	2002-5H467:2	2	P	28
131	2006-5D6 剖 L5:3	3	P	22	316	2002-5H467:3	2	P	28
132	2002- 5T15(4)A:5	3	P	23	317	2002-5H467:4	2	P	16
133	2002-	3	P	22	318	2002-5G11:3	2	P	17

	5T15(4)A:6								
134	2002- 5T34(4)D:1	3	P	24	319	2001-5H8:12	2	P	23
135	2006-5VT111 剖 (4) D : 31	3	P	25	320	2001-5H8:15	2	P	22
136	2002- 5T27(4)A:14	4 late	P	20	321	2001-5H30:4	2	P	28
137	2002- 5T34(4)B:8	4 late	P	22	322	2002-5H55:6	2	P	22
138	2002- 5T36(4)A:9	4 late	P	19	323	2002-5H55:8	2	P	30
139	2002- 5T36(4)B:9	4 late	P	20	324	2002-5H121:2	2	P	26
140	2002- 5T36(4)B:14	4 late	P	21	325	2002-5H127:1	2	P	22
141	2006-5VT111 剖 (4) C : 9	4 late	P	19	326	2003-5H188:4	2	P	25
142	2006-5VT115 剖 (4) D : 4	4	P	17	327	2003-5H192:2	2	P	24
143	2006-5VT117 剖 (4) B : 4	4 late	P	18	328	2005-5H412:3	2	P	20
144	2006-5VT117 剖 (4) B : 5	4 late	P	20	329	2002-5H460:3	2	P	21
145	2006-5VT119 剖 (4) B : 13	4 late	P	20	330	2002-5H460:2	2	P	22
146	2006-5D6 剖 (4)A:1	4	P	20	331	2001-5H14:3	3	P	21
147	2006-5D6 剖 (4)D:1	4	P	24	332	2001-5H14:2	3	P	20
148	2002- 5T34(4)A:11	4 late	P	21	333	2002-5H243:8	3	P	24
149	2002- 5T34(4)B:9	4 late	P	23	334	2004-5H299:3	3	P	23
150	2002- 5T35(4)A:14	4 late	P	18	335	2001-5H35:1	3	P	20
151	2006-5VT111 剖 (4) B : 5	4 late	P	25	336	2002-5H80:4	3	P	23
152	2006-5VT115 剖 1 (4) B : 4	4 late	P	20	337	2003-5H180:1	4 late	P	20
153	2006-5D6 剖 (4)D:4	4	P	22	338	2003-5H200:6	4 late	P	20.5
154	2003-5VT36 (4) B : 8	2	P	20	339	2003-5H218:3	4 late	P	21.2

156	2003-5T56 剖 LN3:2	2	P	19	340	2005-5H384:1	4 late	P	20
157	2003- 5T31LE3:3	2	P	23	341	2002-5H47:11	4	P	20
158	2003-5T62 剖 LS3:1	2	P	23	342	9H15:1	1	C	23.5
159	2003-5T62 剖 QS:1	2	P	22	343	3H21:1	2	C	32.4
160	2003- 5T34D6L:3	4	P	20	344	3H21:2	2	C	37.5
161	2003- 5T34D6L:10	4	P	23	345	3H19:3	2	C	35.8
162	2003-5T61 剖 LS2(2):3	2	P	21	346	3T22(4):1	3	C	32
163	2020-5T29 剖 D6 秀 2:5	4	P	18	347	3H23:2	4 late	C	30.6
164	2005-5T103 剖 1D6 秀 : 10	4 late	P	19	348	3H23:3	4 late	C	28
165	2005-5T104 剖 D6 秀 : 3	4	P	20	349	3H23:23	4 late	C	28
166	2003-5T34 剖 2Q1:3	4	P	21	350	3H23:24	4 late	C	19.4
167	2006-5T115 剖 2D6 秀 1:2	2	P	21	351	5H63(2):1	1	P	24
168	2002-5T29 剖 D6L:3	4	P	20	352	5H63(1):8	1	P	21
169	2006-5T23 剖 L2:1	3	P	23	353	5H63(1):7	1	P	23
170	2006-5T23 剖 L2:2	4	P	22	354	5H63(2):2	1	P	23
171	2005-5T104 剖 D11 秀 : 2	4	P	20	355	5H36:15	2	P	33
172	2005-5T104 剖 D11 秀 : 1	4	P	23	356	5H36:17	2	P	20.5
173	2002-5H119:4	1	P	21	357	5H54(1):30	2	P	23
174	2002-5H119:6	1	P	18	358	5H54(1):29	2	P	21
175	2002-5H222:1	1	P	24	359	5H62:13	2	P	17
176	2002-5H222:2	1	P	16	360	5H62:11	2	P	17
177	2002-5G10(2):2	1	P	24	361	5H62:10	2	P	24
178	2002-5G10(2):3	1	P	28	362	5H62:9	2	P	24
179	2002- 5G10(2):20	1	P	23	363	5F5:8	2	P	18.8
180	2002-	1	P	26	364	5F5:11	2	P	25

	5G10(2):23								
181	2002-5G10(2):11	1	P	22.7	365	5H37(1):12	3	P	28
182	2002-5G10(2):25	1	P	15	366	5T4730L1:3	4	P	16
183	2002-5G10(1):17	2	P	22.5	367	5T4730L1:4	4	P	18
184	2002-5G10(1):21	2	P	18.8	368	2004-5H348:1	4	W	21
369	2004-5H354:1	4late	W	18	387	2004-5H331:34	4late	W	28
370	2004-5H267:19	4late	W	20	388	2004-5H331:13	4	W	23
371	2004-5H269:5	4late	W	20	389	2004-5H331:14	4	W	21
372	2004-5H269:6	4late	W	21	390	2004-5H374:6	4late	W	23
373	2004-5H278:24	4late	W	20	391	2004-5H374:4	4late	W	19
374	2004-5H278:26	4late	W	22	392	2004-5H374:5	4late	W	21
375	2004-5H290:14	4late	W	24	393	2004-5H379:8	4late	W	24
376	2004-5H290:15	4late	W	31	394	2004-5H380:4	4late	W	19
377	2004-5H303:5	4late	W	19	395	2004-5H380:5	4late	W	19
378	2004-5H303:6	4late	W	31	396	2004-5H393:1	4late	W	21
379	2004-5H303:7	4late	W	26	397	2004-5T85(4)A:3	4late	W	20
380	2004-5H303:8	4late	W	20	398	2004-5T89(4)C:4	4late	W	18
381	2004-5H303:9	4late	W	17	399	2004-5T89(4)F:6	4late	W	24
382	2004-5H323:33	4late	W	21	400	2004-5T89(4)F:7	4late	W	17
383	2004-5H323:37	4late	W	19	401	2004-5T90(4)B:7	4late	W	21
384	2004-5H330:20	4late	W	18	402	2004-5T85(4)A:5	4late	W	22
385	2004-5H331:17	4late	W	20	403	2004-5T85(4)A:6	4late	W	21
386	2004-5H331:23	4late	W	20					

Table 22 The rim size of Cooking Li from Erlitou site

#	Sample	Phase	Context	Rim	#	Sample	Phase	Context	Rim
1	4H10:12	3	W	18	47	2003-5H232 : 7	4 late	P	16
2	4H57:97	3	W	13.1	48	2003-5H247 : 3	4 late	P	28
3	4H57:98	3	W	16.9	49	2001-5H272:10	4 late	P	13
4	4H57:96	3	W	17.5	50	2001-5H272:12	4 late	P	13.3
5	4H76:94	3	W	24	51	2004-5H285:15	4 late	P	20
6	2H226:23	3	C	16	52	2003-5G14:44	4 late	P	15
7	3·5H240:59	3	C	14.4	53	2003-5G14:96	4 late	P	14
8	C : 41	3	C	16.2	54	2003-5G14:80	4 late	P	13
9	9H30:1	3	C	18	55	2003-5G14:87	4 late	P	14
10	9M9:1	3	C	19.3	56	2003-5G14:89	4 late	P	16.5
11	82YL9M9:1	3	C	17.5	57	2003-5G14:91	4 late	P	14
12	81YL4T22(3):1	3	W	22.5	58	2003-5G14:93	4 late	P	18
13	5H101:12	4 late	P	12.8	59	2003-5G14:95	4 late	P	13
14	5H101:11	4 late	P	15.9	60	2003-5G14:101	4 late	P	12
15	2·5T126(3):11	4	P	17.9	61	2003-5H203:7	4 late	P	15
16	5H83:43	4 late	P	15	62	2004-5H260:5	4 late	P	14
17	5H19:14	4	P	33.5	63	2002-5T27(3):1	4	P	14
18	5H83:18	4 late	P	32	64	4H93:11	4	W	15.9
19	5H83:30	4 late	P	16.4	65	2000-3T3(5)B:15	4	C	24
20	5T214(3)B:11	4	P	17.2	66	2000-3H13(1) : 39	4 late	C	16
21	5H54:12	4	P	18.2	67	2000-3H8:18	4 late	C	17
22	5H53:22	4 late	P	19.2	68	2000-3H24:35	4 late	C	12.5
23	5H53:13	4 late	P	19.7	69	2000-3H24:50	4 late	C	21
24	2003-VT36(4) A : 2	4 late	P	10	70	2000-3H24:5	4 late	C	30.8
25	2003-VT36(4) B : 7	4 late	P	9	71	2000-3H24:112	4 late	C	31
26	2002-5T26(4)A:3	4 late	P	12	72	2000-3H24:34	4 late	C	23
27	2002-5T27(4)A:11	4 late	P	16	73	3H23:6	4 late	C	20.5
28	2002-5T27(4)A:17	4 late	P	18	74	3H23:8	4 late	C	16.7
29	2002-	4 late	P	17	75	3H8:5	4 late	C	15

	5T27(4)A:2 1								
30	2003-5T36 (4) A : 3	4 late	P	15	76	86YL4T5(3B):1	4	W	27
31	2003-5T36 (4) A : 8	4 late	P	12	77	81YL4M2:1	4	W	14.5
32	2003-5T36 (4) B : 10	4 late	P	16	78	83YL3C:1	4	C	19.2
33	2003-5T36 (4) B : 12	4 late	P	15	79	87YL7H2:1	4	C	14.5
34	2003-5T36 (4) B : 16	4 late	P	15	80	84YL4H122:1	4	W	28.5
35	2002- 5T62(4)A:5	4 late	P	19	81	85YL4(2A):1	4	W	21.5
36	2005- 5VT105 剖 (4) A : 1	4 late	P	18	82	82YL8H9:1	4	C	17
37	2005- 5VT107 剖 (4) : 2	4 late	P	16	83	84YL4M60:4	4	W	11.7
38	2006- 5VT111 剖 (4) B : 3	4 late	P	16	84	92YL9H111:4	4	C	16.5
39	2005-5T104 剖(4)A:1	4	P	16	85	81YL3h23:8	4 late	C	14.7
40	2002- 5H87:15	4 late	P	13.5	86	86YL6H5:4	4	C	23.5
41	2002- 5H111:18	4 late	P	15.5	87	85YL6H5:7	4	C	10
42	2002- 5H112:20	4 late	P	13.8	88	2004-5T85(4)A:5	4 late	W	16
43	2002- 5H112:51	4 late	P	12	89	2004-5H330:19	4 late	W	21
44	2002- 5H112:52	4 late	P	14	90	2004-5H331:35	4 late	W	14
45	2002- 5H147:8	4 late	P	17	91	2000-3T3(5)B:11	4	C	22
46	2003- 5H228 : 10	4 late	P	11.8					

Table 23 The rim size of Storage Zun from Erlitou site

#	Sample	Phase	Context	Rim	#	Sample	Phase	Context	Rim
1	2003-M7:1	2	M	19.4	52	2005-5T105(4):4	4 late	P	31
2	5M23:2	2	M	16.5	53	2006-5VT111 剖 (4) C : 5	4 late	P	33
3	6M8:5	2	M	20.7	54	2002-5T22(4)B:5	4	P	31
4	2004-5M19:4	2	M	19.3	55	2003- 5T34(4)A:21	4 late	P	32
5	2002- 5T27(4)A:37	2	P	22	56	2005-5T113(4):2	4 late	P	32
6	2002- 5G38(1) : 7	2	P	36	57	2006-5T103 剖 2D6 秀 : 3	4 late	P	28
7	2001-5H28:5	2	P	26	58	2005-5T104 剖 D6 秀 : 1	4	P	45
8	2002-5H92:12	2	P	25.2	59	2002-5T29 剖 D6L:4	4	P	30
9	9H30:3	2	C	30	60	2002-5H92:44	4	P	27.8
10	9H30:4	2	C	27	61	2002-5H112:17	4 late	P	29.88
11	9M15:2	2	C	22.5	62	2002-5H150:19	4 late	P	38
12	3T5(6):2	2	C	29.8	63	2003-5H174:3	4 late	P	35
13	4M17:4	2	M	20.7	64	2003-5H228 : 8	4 late	P	25
14	6M28:8	2	M	28.2	65	2003-5H232 : 1	4 late	P	33
15	2006-5D6 剖 L5:1	3	P	23	66	2001-5H272:19	4 late	P	36.8
16	2006-5VT111 剖 (4) D : 26	3	P	20	67	2006-5H447:13	4 late	P	35
17	2002-5H92:8	3	P	33	68	2006-5H447:31	4 late	P	37
18	2002-5H463:4	3	P	33	69	2001-5H465:9	4	P	35
19	2002-5H463:5	3	P	38	70	2003-5G14:49	4 late	P	38.8
20	2002-5H463:6	3	P	40	71	2003-5G14:110	4 late	P	47
21	2002-5H143 : 9	3	P	33	72	2002-5H132:6	4 late	P	43
22	2001-5H15:3	3	P	31	73	2003-5T35LE2:5	4 late	P	38
23	2001-5H14:1	3	P	31	74	2003-5T35LE2:3	4 late	P	29
24	2002-5H99:1	3	P	34	75	2003-5T34D6L:5	4 late	P	31
25	2002-5H62:10	3	P	25.5	76	2004-5T99(4)B:1	4	P	25
26	2005-5H411:3	3	P	41	77	2004-5H341:6	4 late	P	26
27	2000- 3T4(17):12	3	C	29	78	2004-5H267:24	4 late	P	28
28	2000- 3T4(16):12	3	C	33	79	2004-5H290:12	4 late	P	39
29	2000-3H20 : 14	3	C	30	80	2004-5H331:26	4 late	P	30

30	2000-3H13 (1) : 10	3	C	46	81	2004-5H374:2	4 late	P	32
31	2000-3H13 (3) : 12	3	C	34	82	2000-3T4(13):3	4	C	32
32	2000-3H13 (2) : 5	3	C	31	83	2000-3T4(11):18	4 late	C	36
33	2000-3H13 (1) : 30	3	C	33	84	2000-3T4(11):30	4 late	C	31
34	2000-3H9:2	3	C	32	85	2000-3T4(14):5	4	C	32
35	2000-3H9:3	3	C	44	86	2000-3T4(14):8	4	C	34
36	6M9 东 H:1	4	M	31.8	87	2000-3T1(9):8	4 late	C	39
37	6M11:3	4	M	23.2	88	2000-3T3(5)B:24	4 late	C	32.8
38	6M1:3	4	M	27.6	89	2000-3T3(5)B:32	4 late	C	35.5
39	2003-M11:4	4 late	M	23.4	90	2000-3T4(10):14	4 late	C	29
40	6M9:14	4	M	31	91	2000-3T2(5)A:24	4 late	C	41
41	6M9:13	4	M	35	92	2000-3H24:56	4	C	51
42	5H101:17	4 late	P	31.5	93	2000-3H24:57	4	C	24
43	5H101:25	4 late	P	44	94	2000-3H24:58	4	C	34
44	5H83:24	4 late	P	34.5	95	2000-3H24:65	4	C	32
45	5H1:11	4	P	35.5	96	2000-3H24:72	4	C	54
46	2·5H133:11	4	P	36	97	2000-3H24:109	4	C	32
47	5T214(3)B:13	4	P	30.5	98	2000-3H24:119	4	C	28.8
48	5T214(3)A:11	4	P	15	99	2000-3H24:113	4	C	39
49	5H82:15	4	P	21	100	2000-3H24:111	4	C	35
50	2002- 5T22(4)B:1	4	P	32.2	101	2000-3H38:4	4	C	31
51	2003- 5T34(4)B:13	4 late	P	34					

Table 24 The rim size of Serving Dou from Erlitou site

#	Sample	Phase	Context	Rim	#	Sample	Phase	Context	Rim
1	2·5H148:20	1	P	20	55	2001-5M1:9	2	M	16.2
2	2·5H148:11	1	P	16	56	2002-5M3:6	2	M	16
3	9H1:2	1	C	20.7	57	2002-5M3:26	2	M	20.8
4	2·5T104(6):16	1	P	15	58	2002-5M3:29	2	M	20.2
5	2·5T110 (5)B:11	1	P	15	59	2002-5M4:3	2	M	19
6	4T8(6):11	1	W	16	60	2002-5M4:10	2	M	16.5
7	2002-5H119:3	1	P	18	61	2004-5M19:5	2	M	21
8	5D2T1(6):2	2	P	16.7	62	9M20:7	2	M	18.6
9	2002-5T6(5)B:8	2	P	20	63	81YLV5:2	2	M	23
10	2002-5G10(1):8	2	P	18	64	81YLV5:3	2	M	18.5
11	2002-5G38(2):16	2	P	18	65	6M49:5	2	M	19.5
12	2002-5G38(1) : 56	2	P	14.5	66	2·5H158:12	3	P	15.1
13	2002-5H57:6	2	P	15	67	2H225:11	3	P	12.7
14	2002-5H102:5	2	P	20.5	68	2·5T117(4):16	3	P	14
15	2003-5H211:13	2	P	20	69	2006-5D6 剖 L5:2	3	P	21
16	2003-5H211:12	2	P	20	70	2002-5T5(4):2	3	P	20
17	2001-5G2:6	2	P	14	71	2001-5H27:10	3	P	22
18	2001-5H12:13	2	P	18	72	2001-5H27:14	3	P	20
19	2001-5H28:26	2	P	21	73	2001-5H15:4	3	P	18
20	2001-5H28:16	2	P	20	74	2006-5H446:2	3	P	21
21	2001-5H44:8	2	P	14	75	2001-5H40:3	3	P	16.5
22	2001-5H44:14	2	P	20	76	2002-5H67:3	3	P	17
23	2001-5H44:17	2	P	17	77	2001-5H26:1	3	P	18
24	2001-5H45:18	2	P	12	78	4H34:12	3	W	16.9
25	2002-5H84:3	2	P	11.7	79	4H76:105	3	W	20
26	2002-5H117:8	2	P	16	80	9M8:6	3	M	12.6
27	2002-5H92:11	2	P	19	81	9M8:7	3	M	18.9
28	2002-5H92:35	2	P	12	82	9M9:3	3	M	16.5
29	2003-5H247 : 6	2	P	17	83	6M25:3	3	M	24
30	2002-5H156:2	2	P	17	84	6M41:3	3	M	21
31	2002-5H163:5	2	P	22	85	6M41:5	3	M	15.8
32	2005-5H409:1	2	P	23	86	6M20:5	3	M	19.5
33	2004-5H293:6	2	P	19	87	6M23:3	3	M	16
34	4H63:32	2	W	20.6	88	6M20:6	3	M	10.7
35	2004-5T84 秀 2:2	2	W	21.5	89	5H101:14	4 late	P	19.5
36	2004-5H308:18	2	W	18	90	5T214(3)B:12	4	P	21
37	2004-5H312:10	2	W	16	91	5H83:39	4	P	22

38	2000-3H1:13	2	C	21	92	2002-5T27(4)A:40	4	P	19
39	2000-3H1:23	2	C	9.8	93	2002-5H147:9	4	P	19
40	4M6:7	2	M	19.7	94	2005-5H405:4	4	P	16
41	5M23:7	2	M	19.7	95	2003-5G14:97	4 late	P	14
42	4M18:1	2	M	21.5	96	2003-5H203:4	4	P	17
43	5M15:6	2	M	20.5	97	2000-3T1(7):26	4 late	C	20
44	4M6:8	2	M	21	98	2000-3T1(6):1	4 late	C	14.5
45	5M15:10	2	M	20.5	99	2000-3T1(9):7	4 late	C	17
46	4M8:8	2	M	21	100	2000-3H24:48	4 late	C	16
47	4M15:5	2	M	16.8	101	5M21 : 2	4 late	M	21
48	6M8:3	2	M	20.8	102	5M21 : 5	4 late	M	16.5
49	4M14:4	2	M	21.3	103	2003-M11:3	4	M	14
50	5M23:6	2	M	15.8	104	2004-5M17:2	4	M	15.3
51	4M8:7	2	M	16.5	105	6M3:3	4	M	20.5
52	5M15:18	2	M	17.6	106	6M3:4	4	M	16
53	4M14:2	2	M	15.8					
54	5M15:1	2	M	16.7					

Table 25 The height size of Jue from Erlitou site

#	Sample	Phase	Context	White or not	Height
1	2001-5M1:8	2	M	No	16.9
2	2001-5M1:10	2	M	Yes	19
3	4M11:1	2	M	No	17.9
4	5M22:1	2	M	No	12.7
5	5M15:3	2	M	No	19
6	4M11:5	2	M	No	20.8
7	9M15:5	2	M	No	16.4
8	9M20:10	2	M	No	15.7
9	6M49:3	2	M	No	18.8
10	84YL4T53(4C):1	2	W	Yes	18.6
11	87YL6M49:3	2	M	No	19
12	87YL6M43:3	2	M	No	19
13	82YL9M20:10	2	M	No	15
14	84YL4M51:3	2	M	Yes	16
15	82YL9M15:5	2	M	No	16.2
16	83UL4M45:1	2	M	No	13
17	94YL12M1:1	2	M	No	14.8
18	2002-5M4:7	2	M	No	13.3
19	2002-5H88:2	2	P	No	16.6
20	4H76:81	3	W	No	16.6
21	6M7:5	3	M	No	17.4
22	3M3:7	3	M	No	18.3
23	9M8:4	3	M	No	16.2
24	80YL5M3:7	3	M	No	17.5
25	87YL4M44:5	3	M	No	15.6
26	82YL9M8:4	3	M	No	15.8
27	90YL9M1:2	3	M	No	15
28	6T3(2)下 : 13	4		No	16.4
29	6KM6 上 : 3	4	M	No	15.8
30	6M11:20	4	M	No	18.3
31	84YL6M11:20	4	M	No	18
32	82YL4M13:4	4	M	No	16.9
33	85YL6M13:3	4	M	No	17.4

Table 26 The height size of He from Erlitou site

#	Sample	Phase	Context	White or not	Height
1	5M23:1	2	M	No	22.5
2	4M8:9	2	M	No	22.3
3	4M11:2	2	M	No	19.8
4	4M18:7	2	M	No	42.3
5	4M14:6	2	M	No	24.6
6	6M8:1	2	M	No	28.5
7	4M17:3	2	M	No	20.3
8	2006-5VT117 剖 (5) C : 19	2	P	No	25.9
9	2001-5H45:25	2	P	No	23
10	2001-5M1:7	2	M	Yes	42.9
11	2001-5M1:17	2	M	Yes	31.8
12	2002-5M3:30	2	M	No	24.6
13	2002-5M3:9	2	M	No	24.4
14	2002-5M4:6	2	M	No	23.5
15	81YLV5:4	3	M	Yes	26.5
16	82XL9M20:9	2	M	No	22.5
17	85YL6M7:3	2	M	No	27
18	84YL4M51:2	2	M	No	21
19	81YL5M5:4	3	M	No	27
20	83YL4M34:2	2	M	No	26
21	82YL9M15:4	2	M	No	24.6
22	83YL4M45:2	2	M	No	20
23	84YL4T15(2B):1	2	W	Yes	28
24	94YL12M2:7	2	M	Yes	21.7
25	6M7:1	3	M	No	25.4
26	3KM2:4	3	M	No	22.9
27	6KM3:10	3	M	No	24
28	3M2:7	3	M	No	22.5
29	3M3:8	3	M	No	25.5
30	9M20:9	3	M	No	22.5
31	9M15:4	3	M	No	24.6
32	6M28:5	3	M	No	24.2
33	82YL9M14:3	3	M	No	25.2
34	87YL4M44:6	3	M	No	21
35	82YL9M8:5	3	M	No	23
36	90YL9M1:1	3	M	No	24.2
37	80YL3M2:7	3	M	No	22.5
38	85YL6M14:1	3	M	No	24
39	4M12:1	4	M	No	23.9
40	2M101:1	4	M	No	19.9

41	6M6:1	4	M	No	21.5
42	9M8:5	4	M	No	22.5
43	6M9:5	4	M	Yes	22.7
44	6M6:4	4	M	Yes	23.1
45	6M11:21	4	M	Yes	22.1
46	6M11:22	4	M	Yes	23.2
47	6M57:19	4	M	No	22.8
48	84YL6M6:4	4	M	No	22.8
49	84YL6M11:22	4	M	No	23
50	84YL6M11:21	4	M	No	22
51	82YL4M13:5	4	M	No	23.4
52	85YL6M13:2	4	M	No	23.1
53	87YL4M1:3	4	M	No	22.4
54	87YL6M57;19	4	M	No	22.8
55	85YL5H27:8	4	P	No	21.5

Sample 4, 10,11 is the Outliers.

#5 other information

Table 27 White pottery samples in the Erlitou site

#	Type	Chinese name	Sample	Period	Context
1	Gui	鬶	2·5T104(4):17	2	P
2	He	盃	3KM2:4	3	M
3	Jars	圆腹罐	2000-3T4(15):22	3	C
4	Yan	甗	2004-5T83 剖 Q3:13	3	W
5	He	盃	2004-5T84 夯 2:4	2	W
6	He	盃	2004-5H308:17	2	W
7	Jue	爵	2004-5H308:16	2	W
8	Foot pieces	白陶袋足	2004-5H364:7	?	W
9	Yan	甗	2002-5T14(6):6	2	P
10	Gui	鬶	2006-5VT117 剖 (5) C : 4	2	P
11	Jue	爵	2002-5T30(5)A:20	2	P
12	He	盃盖	2002-5T5D3L : 4	?	P
13	He	盃	2006-5T115 剖 1D6 夯:5	4	P
14	He	盃	2002-5T29 剖 D6L:2	4	P
15	He	盃	2002-5G10(1):29	2	P
16	Zun	大口尊	2002-5G38(1) : 7	2	P
17	He	盃盖	2002-5G38(1) : 64	2	P
18	Jar	圆腹罐	2002-5H104:10	2	P
19	Weng	瓮	2002-5H109:4	2	P
20	Cylindrical ware	筒形白陶器	2009-5T56G17:6	3	P
21	pad	花纹陶片	2003-5H198:15	4	P
22	He	盃	2001-5M1:7	2	M
23	He	盃	2001-5M1:17	2	M
24	He	爵	2001-5M1:10	2	M
25	Douli-shaped ware	斗笠形器	2002-5M3:1, 2,3	2	M
26	Douli-shaped ware	斗笠形器	2002-5M3:1, 2,3	2	M
27	Douli-shaped ware	斗笠形器	2002-5M3:1, 2,3	2	M
28	Gui	鬶	2002-5M5:19	2	M
29	He	盃	2002-5M5:1	2	M
30	He	盃	2002-5M5:5	2	M
31	Ding	鼎	2001-5T4D2HC:39	2	P
32	Yan	甗	2001-5T4D2HC:19	3	P

33	Grate	白陶算子	2001-5T4D2HC:5	3	P
34	He	盃	2003-5H215:4	2	P
35	Cylindrical ware	筒形白陶器	2001-5H29:9	2	P
36	pad	花纹陶片	2002-5H62:9	2	P
37	Jar	高领罐	2005-5H401:4	2	P
38	Jue	爵	3M2:6	3	M
39	Jue	爵	5M3:7	3	M
40	He	盃	3M2:7	3	M
41	He	盃	5M3:8	3	M
42	He	盃	6M6:1	4	M
43	He	盃	81YLV5:4	2	M
44	He	盃	81YLV1:1	3	M
45	He	盃	6M9:5	4	M
46	He	盃	6M6:4	4	M
47	He	盃	6M11:21	4	M
48	He	盃	6M11:22	4	M
49	Gui	鬯	6M49:2	2	M

Table 28 White pottery samples outside the Erlitou site

#	Type	Chinese name	Sample	Period	Context	Location
1	He	盃	M5:1	2	M	Dongmagou
2	Gui	鬶	M8:5	2	M	Dongmagou
3	He	盃	T82M3:6	1	M	Nanzhai
4	Jue	爵	T82M3:4	1	M	Nanzhai
5	He	盃	T85M26:1	2	M	Nanzhai
6	Gui	鬶	T85M33:3	2	M	Nanzhai
7	He	盃	T91M28:2	4	M	Nanzhai
8	Jue	爵	T91M28:1	4	M	Nanzhai
9	He	盃	T8(2):3	2	T	Baiyuan
10	Jue	爵	T2(3)M21:1	2	M	Baiyuan
11	Jue?	爵?	H71:4	2	H	Zhengyao
12	Jue	爵	J4:21	3	J	Zhengyao
13	Gui	鬶	M5:5	1	M	Shaochai
14	Jiao	角	H88:2	2	H	Zaojiaoshu
15	Jue	爵	H107:5	3	H	Zaojiaoshu
16	Gui	鬶	T44H191:8	2	H	Haojiatai
17	He	盃	YPNT93H81:1	2	H	Nanzhai
18	He	盃	YPNT90M10:6	4	M	Nanzhai
19	Jue	爵	YPNT90M10:5	4	M	Nanzhai
20	Jue	爵	YPNT82M3:4	1	M	Nanzhai
21	Jue	爵	YPNT85M32:5	2	M	Nanzhai
22	Jue	爵	YPNT86(3):4	2	T	Nanzhai
23	Wangzhui	网坠	2004-H90:27	3	H	Nanwa
24	Foot	袋足	2004-H90:1	3	H	Nanwa
25	Gui	鬶	2004H363:1	2early	H	Nanwa
26	base	器底	2004H228:51	1	H	Nanwa
27	Jue	爵鬶	2004H228:85	1	H	Nanwa
28	Jue	爵足	none	1	H	Nanwa
29	He	盃盖	2004H149:1	2early	H	Nanwa
30	Jue	爵足	2004H149:5	2early	H	Nanwa
31	Wangzhui	网坠	2004H149:3	2early	H	Nanwa
32	handle	陶鬶	2004H153:85	3	H	Nanwa
33	Jar	白陶罐	2004H120:2	3	H	Nanwa
34	Foot	袋足	2004H120	3	H	Nanwa
35	Jue	爵	2004H242:4	2early	H	Nanwa
36	Foot	袋足	2004J2:8	2late	J	Nanwa
37	Jue	爵	2004J2:3	2late	J	Nanwa
38	Wangzhui	网坠	2004J2	2late	J	Nanwa
39	Base	器底	2004-T7138(5):34	2early	T	Nanwa

40	Wangzhui	网坠	2004H441:20	2early	H	Nanwa
41	Gui	鬻	2004-H17:10	2early	H	Nanwa
42	Gu	觚	2004-H17:12	2early	H	Nanwa
43	Gui	鬻	2004H19:155	2early	H	Nanwa
44	Gui	鬻	2004H19:153	2early	H	Nanwa
45	Gui	鬻	2004H19:109	2early	H	Nanwa
46	Gui	鬻	2004H19:110	2early	H	Nanwa
47	Gui	鬻	2004H19:111	2early	H	Nanwa
48	Gui	鬻	2004H19:154	2early	H	Nanwa
49	Gui	鬻	2004H19:158	2early	H	Nanwa
50	Jue	爵	2004H19:157	2early	H	Nanwa
51	Jue	爵	2004M1:7	2late	M	Nanwa
52	Jue	爵	2004-2T1G1:1	2	T	Nanwa
53	Jue	爵	2004-2T1G1:2	2	T	Nanwa
54	Gui	鬻	2004-2T6G1:7	2	T	Nanwa
55	Gu	觚	2004H456:1	2early	H	Nanwa
56	Wangzhui	网坠	2005H96:85	2early	H	Nanwa
57	He	盃盞	2005H96	2early	H	Nanwa
58	Foot	带足	2005H96	2early	H	Nanwa
59	Gui	鬻	2005H133:95	2late	H	Nanwa
60	Jue	爵足	2005H133	2late	H	Nanwa
61	Jue	爵	2005H66:91	2early	H	Nanwa
62	He	盃	2005H66	2early	H	Nanwa
63	Gui	鬻	2005H67:71	2early	H	Nanwa
64	He	盃	2005H67	2early	H	Nanwa
65	Jue	爵	2005H56:70	2late	H	Nanwa
66	Gui	鬻	2005H56	2late	H	Nanwa
67	He	盃盞	2005T7842(4):70	2	T	Nanwa
68	Wangzhui	网坠	2004H26:1	2	H	Nanwa
69	Base	器底	2004H265:3	2early	H	Nanwa
70	He	盃流	2004T7073(2):12	2	T	Nanwa
71	Ling	铃	2004H418:10	2late	H	Nanwa
72	Wangzhui	网坠	2004H194:2	2early	H	Nanwa
73	Wangzhui	网坠	2004H241:4	2early	H	Nanwa
74	Gui	鬻	2005H107:100	2early	H	Nanwa
75	Jar	原始瓷罐	2005H107:102	2early	H	Nanwa
76	Jue	爵	2005-1T7441(3):15	2	T	Nanwa
77	Wangzhui ?	网坠 ?	2005H53:30	2	H	Nanwa
78	He	盃盞	2004H6	2early	H	Nanwa
79	He(or Gui)	盃 (鬻)	2004H8	2early	H	Nanwa
80	He(or Gui)	盃 (鬻)	2004H9	2early	H	Nanwa
81	Foot	带足	2004H10	2early	H	Nanwa

82	Jue	爵	2004H15	2early	H	Nanwa
83	Gui	鬻	2004H27	2early	H	Nanwa
84	Foot	袋足跟	2004H46	3	H	Nanwa
85	Jue	爵	2004H75	2late	H	Nanwa
86	He(or Gui)	盃 (鬻)	2004H75	2late	H	Nanwa
87	Gui	鬻口	2004H127	2late	H	Nanwa
88	Gui	鬻	2004H144	2late	H	Nanwa
89	Jue	爵	2004H144	2late	H	Nanwa
90	Foot	带足	2004H163	2late	H	Nanwa
91	Gui	鬻裆	2004H166	2early	H	Nanwa
92	Gui	鬻	2004H180	2early	H	Nanwa
93	Gui	鬻盞	2004H181	2early	H	Nanwa
94	Jue	爵足	2004H200	2late	H	Nanwa
95	Foot	袋足	2004H188	3	H	Nanwa
96	Foot	袋足跟	2004H201	2early	H	Nanwa
97	Wangzhui	网坠	2004H206	2early	H	Nanwa
98	Foot	袋足	2004H207	2late	H	Nanwa
99	Foot	袋足	2004H209	2late	H	Nanwa
100	Gui	鬻盞	2004H217	3	H	Nanwa
101	Gui	鬻流	2004H229	2early	H	Nanwa
102	He(or Gui)	盃 (鬻)	2004H242	2early	H	Nanwa
103	Piece	绳纹陶片	2004H242	2early	H	Nanwa
104	He(or Gui)	盃 (鬻)	2004H253	2late	H	Nanwa
105	Piece	绳纹陶片	2004H253	2late	H	Nanwa
106	Foot	袋足	2004H263	3	H	Nanwa
107	He	盃盞	2004H279	3	H	Nanwa
108	He	盃盞	2004H306	2early	H	Nanwa
109	He	盃顶	2004H331	2late	H	Nanwa
110	Jue	爵足	2004H331	2late	H	Nanwa
111	Jue	爵足	2004H417	2late	H	Nanwa
112	Gui	鬻口	2004H440	2late	H	Nanwa
113	He(or Gui)	盃 (鬻)	2005H1	3	H	Nanwa
114	Jue	爵尾	2005H8	3	H	Nanwa
115	Gui	鬻裆	2005H9	2late	H	Nanwa
116	Jue	爵盞	2005H19	3	H	Nanwa
117	Foot	袋足	2005H22	2late	H	Nanwa
118	Jue	爵足	2005H32	2early	H	Nanwa
119	Foot	袋足	2005H32	2early	H	Nanwa
120	Foot	袋足跟	2005H36	2	H	Nanwa
121	Gui	鬻裆	2005H42	3	H	Nanwa
122	Jue	爵足	2005H44	2early	H	Nanwa
123	Gui	鬻盞	2005H47	2late	H	Nanwa

124	Gui	鬻盞	2005H50	3	H	Nanwa
125	Foot	袋足	2005H64	2early	H	Nanwa
126	He	盞盞	2005H65	3	H	Nanwa
127	Wangzhui	网坠	2005H65	3	H	Nanwa
128	He	盞	2005H72	2late	H	Nanwa
129	He	盞	2005H72	2late	H	Nanwa
130	He	盞	2005H79	2late	H	Nanwa
131	He	盞盞	2005H83	2early	H	Nanwa
132	Wangzhui	网坠	2005H83	2early	H	Nanwa
133	Gui	鬻	2005H84	2late	H	Nanwa
134	He	盞盞	2005H85	2late	H	Nanwa
135	Jue	爵足	2005H85	2late	H	Nanwa
136	Gui	鬻流	2005H85	2late	H	Nanwa
137	He	盞顶	2005H85	2late	H	Nanwa
138	Gui	鬻	2005H87	2early	H	Nanwa
139	Gui	鬻	2005H89	3	H	Nanwa
140	Gui	鬻	2005H90	3	H	Nanwa
141	Foot	袋足	2005H90	3	H	Nanwa
142	He	盞	2005H92	3	H	Nanwa
143	He	盞盞	2005H93	2late	H	Nanwa
144	Jue	爵足	2005H93	2late	H	Nanwa
145	Jue	爵底	2005H110	2late	H	Nanwa
146	Foot	袋足	2005H110	2late	H	Nanwa
147	Wangzhui	网坠	2005H111	2late	H	Nanwa
148	He	盞盞	2005H112	2early	H	Nanwa
149	Foot	带足	2005H112	2early	H	Nanwa
150	Wangzhui	网坠	2005H112	2early	H	Nanwa
151	Gui	鬻裆	2005H116	2late	H	Nanwa
152	Jue	爵足	2005H131	2late	H	Nanwa
153	Gui	鬻裆	2005H131	2late	H	Nanwa
154	Wangzhui	网坠	2005H134	2late	H	Nanwa
155	Gui	鬻	2005H136	2early	H	Nanwa
156	Gui	鬻口	2005H137	2early	H	Nanwa
157	Foot	袋足	2005H137	2early	H	Nanwa
158	Wangzhui	网坠	2005H137	2early	H	Nanwa
159	Gui	鬻	2005H138	2early	H	Nanwa
160	Jue	爵	2005H139	2early	H	Nanwa
161	Jue	爵足	2005H140	2early	H	Nanwa
162	Jue	爵底	2005H147	4early	H	Nanwa
163	He	盞盞	2005H147	4early	H	Nanwa
164	Foot	袋足	2005H147	4early	H	Nanwa
165	Gui	鬻	2005H159	2early	H	Nanwa

166	Jue	爵	2005H166	2late	H	Nanwa
167	Gui	鬶	2005H166	2late	H	Nanwa
168	Gui	鬶	2005H167	2early	H	Nanwa
169	Jue	爵底	2005H167	2early	H	Nanwa
170	He	盃	2005H185	2early	H	Nanwa
171	Scallop	扇贝	2005H185	2early	H	Nanwa
172	He	盃	2005H189	2early	H	Nanwa
173	Jue	爵盞	2005H189	2early	H	Nanwa
174	He	盃	2005H207	4early	H	Nanwa
175	Foot	袋足	2005H214	2late	H	Nanwa
176	Jue	爵足	2005H232	2early	H	Nanwa
177	He	盃 (鬶)	2005H252	1	H	Nanwa
178	Base	绳纹圜底	2005H255	3	H	Nanwa
179	Foot	袋足	2005H261	2early	H	Nanwa
180	Jue	爵盞	2005H261	2early	H	Nanwa
181	Gui	鬶	2005H263	2early	H	Nanwa
182	Gui	鬶	2006H14	2early	H	Nanwa
183	Jue	爵	None	2	H	Nanwa
184	Jue	爵	T2H4:81	2	T	Xiyacun
185	Jue	爵	T22 (2) b:1	2	T	Yangzhuang
186	Gui	鬶	T15(2):27	2	T	Yangzhuang
187	Gui	鬶	H5:21	2	H	Tuoli
188	He	盃	1T0206H936:7	3	H	Niangniangzhai
189	Jue	爵	1T0206H936:8	3	H	Niangniangzhai
190	Gui	鬶	DT1(2):3	2	T	Dongzhuang
191	He	盃	DH3:2	2	H	Dongzhuang
192	Gui	鬶	M1:4	2	M	Xiaodian
193	Jue	爵	H9:3	2	H	Lusi
194	Jue	爵	H42:24	2	H	Liuzhuang

Table 29 The consumption of cooking vessels in the early period

	D1 north	D2	D4
FUZAO	9	2	3
DING	2	2	1
JIA	12	2	5
LI	20	0	24

Table 30 The distribution of cooking vessels in different functional are

Phase	Context	Jars deep	Jars round	Zeng	Ding	Li
1st	C	14	2	2	5	0
	P	44	11	4	9	0
2rd	C	13	13	4	10	0
	P	131	104	26	42	0
	W	7	12	4	8	0
3rd	C	19	22	6	13	4
	P	45	41	9	12	0
	W	11	9	3	6	6
4th	C	55	34	19	11	16
	P	126	82	28	20	59
	W	4	23	9	6	7

Context P: Palace area; W: Workshop area; C: Commoner area(areas rather than palace and workshop area); M: burials.